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Acropora and *Dascyllus aruanus* (Linnaeus, 1758) - Jolly Buoy, Andaman Islands

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Coral Reefs. Coral reefs are underwater ecosystems typical of tropical seas and oceans. They are constituted by and increase thanks to the sedimentation of the calcareous skeletons of the corals, polypoid animals belonging to the Class Antozoa, phylum Cnidaria. The life of the small polyps that build coral reefs is bound to microscopic algae, the Zooxantellae, that live in symbiosis within them and from which they gain oxygen and precious substances for their nourishment. In addition, the polyps give to the Zooxantellae toxic substances derived from their metabolism. Coral reefs represent a submerged world rich in biodiversity. The unique characteristics of the numerous marine habitats that are created inside the reefs allow life to thrive to thousands of species of fish, crustaceans, molluscs, sponges, algae, echinoderms and other marine organisms. Currently, coral reefs are threatened by human activity and the global climate change, with enormous risks for the survival of entire natural ecosystems.

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To the right, photos by Giusy Causa, Maldives Archipelago, 1984

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Mactra pecchiolii Lawley, 1869 (Bivalvia Mactridae), a "forgotten pliocenic" taxon

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ABSTRACT A fossil bivalve belonging to the Pliocene has been recorded in southern Tuscany. Following bibliographic researches, it has been classified as a previously studied taxon that has never been cited afterwards: *Mactra pecchiolii* Lawley, 1869 (Bivalvia Mactridae). A lagoon environment of salt water has been speculated for this species.

KEY WORDS *Mactra*; Mactridae; fossils; Pliocene.

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INTRODUCTION

The examination of material of Lower Pliocene from southern Tuscany has brought to the discovery of a bivalve never reported, at first glance, and figured as *Mactra* sp. (Brunetti, 2014). After extensive studies, it became clear that this taxon belong to a species previously described as *Mactra pecchiolii* Lawley, 1869, and never again cited afterwards.

MATERIAL AND METHODS

The examined material, sampled during subsurface searches, is from a Zanclean deposit. Usually, the original diagnosis of the specific descriptions is not indicated. However, in this occasion, the immediate comparison of the most important characteristics of the species was necessary.

ABBREVIATIONS AND ACRONYMS. L = maximum width of the shell; ex = specimen/s; CMMB = collection M.M. Brunetti (Navas del Selpillar, Spagna) MGGC = collection Della Bella, Museo Geologico "G. Capellini"of Bologna (Italy).

RESULTS

Systematics

Classis BIVALVIA Linnaeus, 1758
Subclassis HETERODONTA Neumayr, 1884
Order CHAMIDA Pacaud et Le Renard, 1995
Superfamilia MACTROIDEA Vaught, 1989
Familia MACTRIDAE Lamarck, 1809
Genus *Mactra* Linnaeus, 1767
Type species: *Cardium stultorum* Linnaeus, 1758

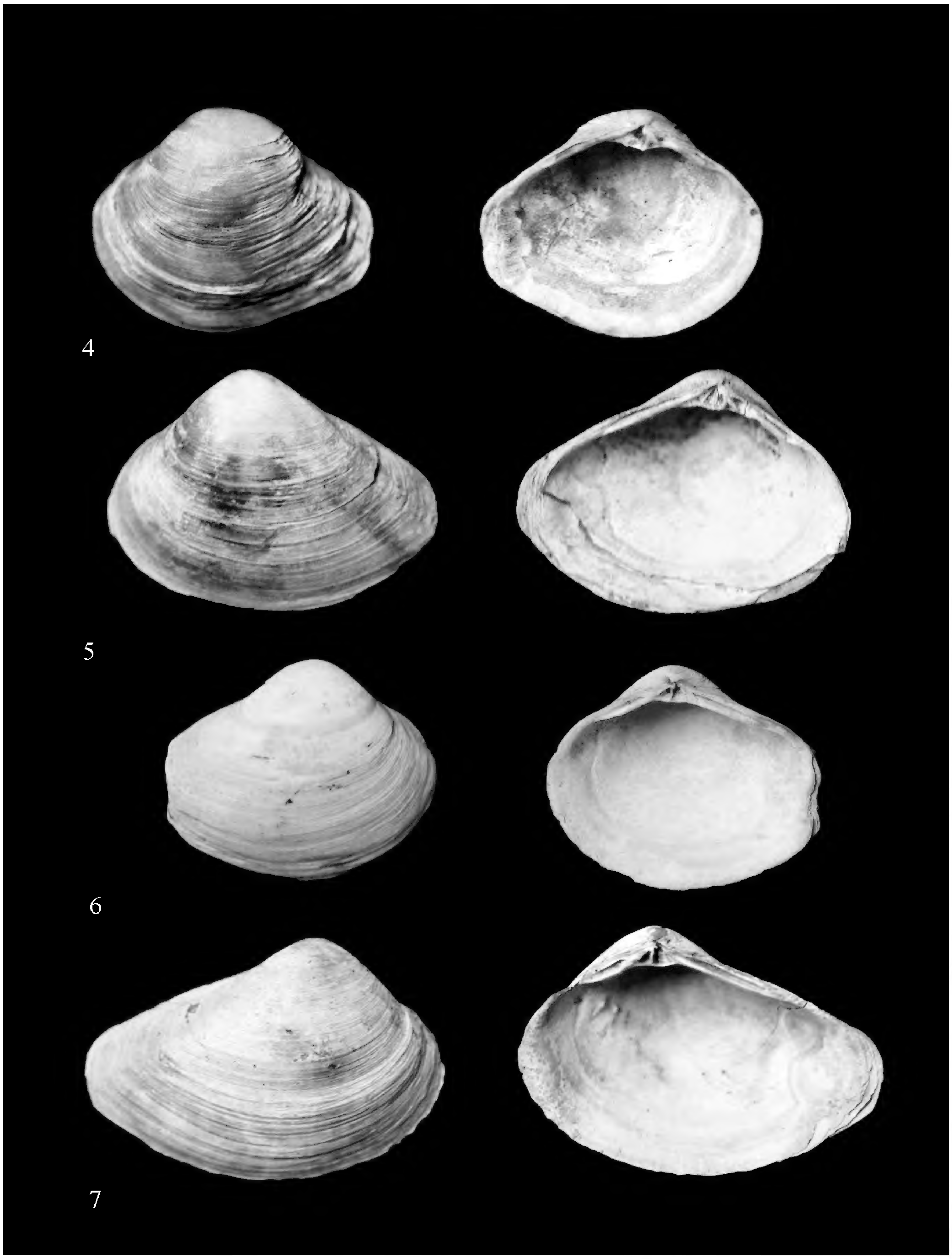
Mactra pecchiolii Lawley, 1869 (Figs. 1–7)

Mactra sp. - Brunetti M., 2014: p. 92.

EXAMINED MATERIAL. Località Monte Antico (Grosseto), Zanclean, 55 ex (MGGC), 35 ex (CMMB).

ORIGINAL DIAGNOSIS (Lawley, 1869). *M. testa trigona, oblonga, turgidula, inaequilatera, solida, laevigata, polita, tranversis irregularis rugosa. Latere antico brevio rotundato. Postico flexuoso, producto attenuato, et obtuso angulato. Umbonitus*

Figures 1–3. *Mactra pecchiolii* Lawley, 1869. Fig. 1: right valve, detail of the hinge, Monte Antico (Grosseto), Zanclean (CMMB). Fig. 2: right valve, Monte Antico (Grosseto), Zanclean, L = 12 mm (CMMB). Fig. 3: original illustration after Lawley, (1869), modified, L = 23 mm.



Figures 4–7. *Mactra pecchiolii* Lawley, 1869. Fig. 4: left valve, Monte Antico (Grosseto), Zanclean, L = 13 mm (MGGC). Fig. 5: left valve, Monte Antico (Grosseto), Zanclean, L = 15.8 mm (MGGC). Fig. 6: right valve, Monte Antico (Grosseto), Zanclean, L = 13 mm (MGGC). Fig. 7: right valve, Monte Antico (Grosseto), Zanclean, L = 17 mm (MGGC).

tumidus, relevatis, obliquis. Valvis intus densis, cardine lato. Vulva tantusque excavata angulo obtuso circumscripta, ad periphaeriam relevata area plicata. Dentibus cardinalibus posterioribus, brevibus; et anteriore bifido; dente sub-cardinale prominente. Fossula cardinali cochleariformis profunda. Impressione muscolare antica profunda, posteriore minus, et cum laevis excavatio pallii. Sinum palleale lato.

DESCRIPTION. Shell is sturdy, swell, equivalve, inequilateral, medium-small dimension (average L = 16 mm). The shape of the valves is triangular, rounded in the back and pointed in the front, rounded under. The sculpture has growthlines with an irregular width, more marked towards the lower border of the valve. Vague and superficial lunule. Protuberant and swell umbones. The pallial line is hard to see, but continuous with deep muscle marks. Posterior cardinal tooth protruding slightly in both valves, median cardinal tooth bifid and protruding in both valves, cardinal fossula deep and elongated.

DISTRIBUTION. Taken into consideration the examined material, the species lived at small depths, probably in lagoon environments of salt water and exclusively in Zanclean.

REMARKS. The specimen illustrated and described by Lawley (1869), even if slightly bigger, can be compared to the material examined for this work. Lawley (1869) report the species for the yellow sand in Bacciano, near Cecinella (Pisa). This author also specify that the material at the "Reale Museo di Pisa" is wrongly stated to be originary from Orciano Pisano (Pisa). The species has been recently discovered only in Monte Antico (Grosseto) of Lower Pliocene (Zanclean), and exclusively in the black clay at *Potamides granosus* f. *basteroti* (De Serres, 1829). This allows to speculate that the habitat of this taxon is a lagoon environment of salt water. See Brunetti (2014) for other insights concerning the location in which this species has been found. By comparing *Mactra pecchiolii* to other similar species, Lawley (1869) noticed a resemblance with *M. triangula* Brocchi, 1814. This species was mentioned by Renier (1804: p. 6), but it was well described and illustrated by Brocchi (1814: p. 535, tav. 13, fig. 7 a-b). *Mactra triangula* is considered by many authors as one of the many varieties of *Spisula subtruncata* (Da Costa, 1778) (Liverani & Tabanelli 2013). Brunetti (2014, p. 92), while illustrating *M. pecchiolii* as *Mactra* sp., speculated a resemblance with the specimen illustrated by Fontannes (1883, p. 23, tav. 1, fig. 27) as *M. triangula*. By carefully rereading the description of the French author, it was clear that this species could be connected to *S. subtruncata* or to a similar species. In the description of the cardinal fossula, Fontannes (1883, p. 23) writes: "*dents latérales lamelliformes, couvertetes des stries longitudinales*". This is one of the morphological character of the genre *Spisula* Gray, 1837, that is missing in *Mactra pecchiolii*. This species has a deep and smooth lateral fossula, while lacking the characteristic lamellae of the *Spisula* genre.

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REFERENCES

Brocchi G.B., 1814. Conchiologia fossile subapennina. Milano, Stamperia Reale, 712 pp.

Brunetti M.M., 2014. Conchiglie fossili di Monte Antico. Tipolito Duemila Group, Campi Bisenzio, Firenze, 118 pp.

Fontannes M., 1879-1883. Les mollusques pliocènes de la vallée du Rhone et du Rousillon. Paris, F. Savy Editeur, 332 pp.

Lawley R., 1869. *Mactra pecchiolii*. Bullettino Malacologico Italiano, 2: 16–18.

Liverani V. & Tabanelli C., 2013. Una collezione di Ludovico Foresti nel Museo Civico di Scienze Naturali di Faenza (Mollusca, Gastropoda, Bivalvia). Quaderno di Studi e Notizie di Storia Naturale della Romagna, 37: 1–8.

Renier S.A.,1804. Tavola alfabetica delle conchiglie adriatiche, nominate dietro il sistema di Linneo, edizione di Gmelin. Padua, pp. v–xiii.

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Preliminary observations on Odonata fauna of Daroji Sloth Bear Sanctuary, Ballari District, North Karnataka (India)

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ABSTRACT The preliminary study was conducted from February 2011 to January 2012 at Daroji Sloth Bear Sanctuary, Hosept. The study revealed the occurrence of a total of 22 species of Odonates in 19 genera belonging to 5 families from the study area. Among them the order Anisoptera which includes dragonflies was predominated with 17 (76%) species, followed by the order Zygoptera which includes damselflies with 5 (24%) species. The family Libellulidae was found to be the most dominant by 13 species with high percentage composition i.e., 76%, followed by the family Coenagrionidae by 3 species with 40% of total odonates species recorded from the study area. The status based on the frequency of occurrence of shows that 8 (36%) were common, 5 (23%) were very common, 3 (14%) were occasional, 4 (18%) were rare and 2 (9%) were very rare. The study highlights the importance and also provides the baseline information on status and composition of Odonates at Daroji Sloth Bear Sanctuary, Ballari District of North Karnataka for research on their biology and the conservation.

KEY WORDS Dragonflies; Damselflies; Odonates; Zygoptera; Anisoptera; Deccan Plateau.

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INTRODUCTION

It is generally difficult to evaluate invertebrate faunal diversity as they are often small, cryptic, and seasonal, making even Red List assessments difficult without considerable resources (Samways & Grant, 2007). Odonata is a primitive group of insects, firstly appeared in carboniferous age and popularly known as dragonflies and damselflies (Mitra, 2006). Globally 5952 species of odonates are known from the world, of which 474 species in 142 genera and 18 families exist in India (Subramanian, 2014). Odonate taxa are ideal models for the investigation of the impact of environmental warming and climate change due to their tropical evolutionary history and adaptations to temperate climates (Nesemann et al., 2011).

Among the invertebrate world, odonates always attract the human beings for their variety of colour, powerful flight and extraordinary sense of vision. The adults are terrestrial and larvae are aquatic. They are valuable as indicators of aquatic and terrestrial ecosystem health and also play a vital role as prey and predator to maintain the balance of trophic levels of food chain and also useful in the

control of harmful insects of crops, orchards and forest, other small insects mosquitoes (Moore, 1997), moths, butterflies and thus have a regulatory impact on agro-forestry (Mitra, 2002).

There are no reports on odonates fauna from this habitat; hence the hitherto study has been conducted to prepare a checklist and to focus on the ecological status of odonates in Daroji Sloth Bear Sanctuary, which might be helpful to improve the habitat and pave the way for future research.

MATERIAL AND METHODS

Study area

Daroji Sloth Bear Sanctuary is unique sanctuary created exclusively for the preservation of sloth bear situated in Ballari District of North Karnataka. The sanctuary is spread over 82.72 km^2 and located between 15°14' to 15°17'N latitude and 76°31' to 76°40'E longitude at an elevation of 647 meters above mean sea level with the temperature ranged between 20°–43°C. The sanctuary is about 50 km from Ballari and about 15km from the Hampi a renowned world heritage site. It belongs to Deccan Plateau and flora consists of primarily dry deciduous scrub and Southern thorn forests.

Sampling methods

The Odonata sampling was carried out from February 2011 to January 2012. The sampling of Odonata was done by direct counts on hourly basis. Data collection was conducted between 09:00 am and 01:00 pm when insects were most active (i.e., during low wind, warm and sunny weather). The odonates observed in the field were photographed by using digital cameras (Canon 400D, Canon 70D and Panasonic DMC-FZ70) and identified by using field identification keys provided by Subramanian (2009, 2005). The taxonomic and nomenclature is used per Subramanian (2014). On the basis of frequency of sighting and abundance, the odonates were categorized into five groups such as, very common (80–100%), common (60–80%), occasional (40–60%), rare (20–40%) and very rare (below 20%) (Adarsh et al., 2015).

RESULTS AND DISCUSSION

A total of 21 species of Odonates in 19 genera belonging to 5 families have been reported. During the study, the Order Anisoptera which comprises dragonflies was the predominant with 17 species belonging to three families and contributed 76%, followed by the Order Zygoptera which comprises damselflies with 5 species belonging two families contributed 24% of total odonates recorded (Table 1).

Among the Order Anisoptera, the family Libellulidae was widely distributed and dominated with high percentage composition i.e., 74% (n=12), while the family Aeshnidae and Gomphidae both were equally distributed with percentage composition i.e., 13% (n=2) each respectively (Table 2). Whereas, among the Order Zygoptera, the family Coenagrionidae was dominated with highest percentage composition i.e., 60% (n=3), followed by the family Platycnemididae with 40% (n=2) (Table 2). The status of odonates based on the frequency of occurrence shows that 33% (n=7) were common, 24% (n=5) were very common, 14% (n=3) were occasional, 19% (n=4) were rare and 10% (n=2) were very rare respectively (Table 1). According to IUCN categorization all the odonate species recorded from the study area comes under 'Least Concern' (LC) category (Table 1).

The present investigation revealed that Anisoptera (dragonflies) was found to be abundant, this might be due to their high dispersal ability and adaptability to wide range of habitats (Kadoya et al., 2004; Suhling et al., 2004). This similar pattern of predominance was also reported from other wetlands i.e., from Komaranahalli Lake (Harisha, 2016a), Kondajji Lake (Harisha, 2016b) and Kundavada Lake (Harisha & Hosetti, 2017a) of Davanagere district, and also from Kuvempu University Campus (Harisha & Hosetti, 2017b) of Shivamogga District of Karnataka, Chinnar Wildlife Sanctuary (Adarsh et al., 2015). Less abundance of Zygoptera (damselflies) may be due to their limited dispersal ability and adaptability (Weir, 1974; Williams 1997; Kadoya et al., 2015). The encounter of damselflies could be attributed to the existence of shade over the habitats from the trees around the water bodies and also to the presence of aquatic vegetation, which could favour the Zygoptera more than the Anisoptera (Subramanian, 2005).

SL. NO	ORDER/FAMILY	COMMON NAME	SCIENTIFIC NAME	S
	ANISOPTERA	DRAGONFLIES		
	AESHNIDAE	DARNERS		
1		Parakeet Darner	*Gynacantha bayadera* Selys, 1891	O
2		Blue Darner	*Anax immaculifrons* Rambur, 1842	C
	GOMPHIDAE	CLUBTAIL		
3		Common Clubtail	*Ictinogomphus rapax* (Rambur, 1842)	VC
4		Common Hooktails	*Paragomphus lineatus* (Selys, 1850)	O
	LIBELLULIDAE	SKIMMERS		
5		Ditch Jewel	*Brachythemis contaminata* (Fabricius, 1793)	VC
6		Ruddy Marsh Skimmer	*Crocothemis servilia* (Drury, 1773)	C
7		Granite Ghost	*Bradinopyga geminata* (Rambur, 1842)	VC
8		Ground Skimmer	*Diplacodes trivialis* (Rambur, 1842)	VC
9		Green Marsh Hawk	*Orthetrum sabina* (Drury, 1773)	VC
10		Wandering Glider	*Pantala flavescens* (Fabricius,1798)	C
11		Crimson Marsh Glider	*Trithemis aurora* (Burmeister,1839)	C
12		Common Picture Wing	*Rhyothemis variegata* (Linnaeus, 1763)	R
13		Long-legged Marsh Glider	*Trithemis pallidinervis* (Kirby, 1889)	VR
14		Black Marsh Trotter	*Tramea limbata* (Desjardins, 1832)	C
15		Red Marsh Trotter	*Tramea basilaris* (Palisot de Beauvois, 1807)	R
16		Coral-tailed Cloud Wing	*Tholymis tillarga* (Fabricius, 1798)	R
17		Yellow-tailed Ashy Skimmer	*Potamarcha congener* (Rambur, 1842)	VR
	ZYGOPTERA	DAMSELFLIES		
	COENAGRIONIDAE	MARSH DART		
18		Pigmy Dartlet	*Agriocnemis pygmaea* Rambur, 1842	O
19		Golden Dartlet	*Ischnura aurora* (Brauer, 1865)	C
20		Blue Grass Dartlet	*Pseudagrion microcephalum* Rambur, 1842	C
	PLATYCNEMIDIDAE	BUSH DART		
21		Blue Bush Dart	*Copera vittata* Selys, 1863	R
22		Yellow Bush Dart	*Copera marginipes* (Rambur, 1842)	R

Table 1. Systematic list of odonates recorded at Daroji Sloth Bear Sanctuary, Ballari District, North Karnataka (India). VC: Very common; C: Common; O: Occasional, VR: Very Rare; R: Rare.

Sl. No.	ORDER/ FAMILY	Sp.	PO	STATUS				
					VC	O	R	VR
I	**Order ANISOPTERA**	**17**	**77%**					
1	Family AESHNIDAE	2	12%	1	-	1	-	-
2	Family GOMPHIDAE	2	12%	-	1	1	-	-
3	Family LIBELLULIDAE	13	76%	5	4	-	2	2
II	**Order ZYGOPTERA**	**5**	**23%**					
4	Family COENAGRIONIDAE	2	60%	2	-	1	-	-
5	Family PLATYCNEMIDIDAE	2	40%	-	-	-	2	-
	OVERALL	**22**	**100%**	**8 (36%)**	**5 (23%)**	**3 (14%)**	**4 (18%)**	**2 (9%)**

Table 2. Order/Family wise species distribution and composition of odonates at Daroji Sloth Bear Sanctuary, Ballari District, North Karnataka (India). Sp.: Species, PO: Percent occurrence. Status = C: Common, VC: Very common, O: Occasional, R: Rare, VR: Very rare.

Figure 1, 2. Odonates from Daroji Sloth Bear Sanctuary, Ballari District, North Karnataka (India): *Orthetrum sabina* (Fig. 1) and *Pantala flavescens* (Fig. 2).

This abundance of Libellulidae and Coenagrionidae in study area might be due to their shorter life cycle and widespread distribution and ability tolerant to wide range of habitats (Norma-Rashid et al., 2001; Gentry et al., 1975; Samways, 1989). The data recorded in the present study may give valuable information about odonate fauna of Daroji Sloth Bear Sanctuary as a baseline data for assessing the changes of environmental conditions in the area, thereby helping in formulating future conservation measures to preserve the wetland habitats and to maintain the ecosystem health (Krishna Prasad et al., 2013).

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REFERENCES

Adarsh C.K., Arunraj R. & Nameer P.O., 2015. Odonata (Insecta) diversity of Chinnar Wildlife Sanctuary, the southern Western Ghats, India. Journal of Threatened Taxa, 7: 6910–6919.

Gentry J.B., Garten C.T., Howell F.G. & Smith M.H., 1975. Thermal ecology of dragonflies in habitats receiving reactor effluent, In: Environmental Effect of Cooling Systems at Nuclear Power Plants. International Atomic Energy Agency, Vienna, 563–574 pp.

Harisha M.N., 2016a. Assessment of status, diversity and threats of odonates in Komaranahalli Lake, Komaranahalli Village, Harihar Taluk, Davanagere District, Karnataka, India. International Journal of Plant, Animal and Environmental Sciences, 6: 122–127.

Harisha M.N., 2016b. Evaluation of Status and Diversity of Odonates of Kondajji Lake, Kondajji Village, Harihar Taluk, Davanagere District, Karnataka, India. Journal of Entomology and Zoology Studies, 4: 384–388.

Harisha M.N. & Hosetti B.B., 2017a. Status, diversity and conservation threats of Odonates in Kundavada Lake, Davanagere district, Karnataka, India. Journal of Entomology and Zoology Studies, 5: 312–316.

Harisha M.N. & Hosetti B.B., 2017b. Conservation status, threats and diversity of Odonates in Kuvempu University Campus, Mid-Western Ghats, Shivamogga district, Karnataka, India. Journal of Entomology and Zoology Studies, 5: 389–393.

Kadoya T., Suda S. & Washitani I., 2004. Dragonfly species richness on man-made ponds: effects of pond size and pond age on newly established assemblages. Ecological Research, 19: 461–467.

Kante Krishna Prasad., Bagari Ramakrishna, Chelmala Srinivasulu & Bhargavi Srinivasulu, 2013. Odonate Diversity of Manjeera Wildlife Sanctuary with notes on Female Polymorphism of *Neurothemis tullia* (Drury, 1773) (Odonata: Libellulidae) and Some Species Hitherto Unreported from Andhra Pradesh, India. Journal of Entomology and Zoology Studies, 1: 99–104.

Mitra T.R., 2002. Geographical Distribution of Odonata (Insecta) of Eastern India. Memories of the Zoological Survey of India, 19: 17.

Mitra T.R., 2006. Handbook on common Indian dragonflies (Insect: Odonata). Zoological Survey of India, Kolkata.

Moore N.W (compiler), 1997. Dragonflies - Status Survey and Conservation Action Plan. IUCN/SSC Odonata Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK, v + 28 pp.

Nesemann H., Shah R.D.T. & Shah D.N., 2011. Key to the larval stages of common Odonata of Hindu Kush Himalaya, with short notes on habitats and ecology. Journal of Threaten Taxa, 3: 2045–2060.

Norma-Rashid Y., Mohd-Sofian A. & Zakaria-Ismail M., 2001. Diversity and distribution of odonata (dragonflies and damselflies) in the fresh water swamp lake, Tasek Bera, Malaysia. Hydrobiologia, 459: 135–146.

Samways M.J., 1989. Taxon turnover in odonata across a 3000 m altitudinal gradient in Southern Africa. Odonatology, 18: 263–274.

Samways M.J. & Grant P.B.C., 2007. Honing Red List Assessments of Lesser-Known Taxa in Biodiversity Hotspots. Biodiversity and Conservation, 16: 2575–2586.

Subramanian K.A., 2005. Dragonflies and damselflies of Peninsular India-A field guide. Indian Academy of Sciences, Bangalore.

Subramanian K.A., 2009. Dragonflies of India - A Field Guide, Vigyan Prasar, Department of Science and Technology, Offset Press, New Delhi, 118 pp.

Subramanian K.A., 2014. A checklist of Odonata of India. Zoological Survey of India, Kolkata, 31 pp.

Suhling F., Schenk K., Padeffke T. & Martens A., 2004. A field study of larval development in a dragonfly assemblage in African desert ponds (Odonata). Hydrobiologia, 528: 75–85.

Weir J.S., 1974. Odonata collected in and near seasonal pools in Wankie National Park, Rhodesia with notes on the physio-chemical environments in which nymphs were found. Journal of the Entomological Society of Southern Africa, 37: 135–145.

Williams D.D., 1997. Temporary ponds and their invertebrate communities. Aquatic Conservation: Marine and Freshwater Ecosystems, 7: 105–117.

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Elevation record for *Myotis daubentonii* (Kühl, 1817) in the Italian Western Alps (Mammalia Chiroptera Vespertilionidae)

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ABSTRACT Five captures of *Myotis daubentonii* (Kühl, 1817) (Mammalia Chiroptera Vespertilionidae) are here reported at an altitudes between 1828 and 2050 meters on the Italian Western Alps in foraging and swarming sites. An immature male was captured at 2050 meters of altitude while looking for food on an alpine wetland, resulting in the altitude record for this species in Italy. Data also confirm the presence of females of the species at an altitudes greater than 2000 meters in swarming sites, raising the recorded altitude limit for the females of this species in Italy.

KEY WORDS Chiroptera; *Myotis daubentonii*; elevation record; Italian Western Alps.

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INTRODUCTION

The Daubenton's bat *Myotis daubentonii* (Kühl, 1817) (Mammalia Chiroptera Vespertilionidae) is one of the most common European vespertilionids (Dietz & Kieefer, 2016), widespread throughout Europe with an areal range spanning from 63°N in Fennoscandia (Ahlén & Gerell, 1989) and Russia (Bogdarina & Strelkov, 2003) to 40°N in Greece (Helversen & Weid, 1990). This species is closely linked to aquatic habitats, where preys are either caught with the wings or "trawled" from the water surface by using the feet and/or the wing membrane (Jones & Rayner, 1988; Kalko & Schnitzler, 1989; Vaughan et al., 1997; Warren et al., 2000).

The reproductive roost of the species are rare above 900 meters of altitude, although presence records are reported up to 1700 meters during summer (Arthur & Lemaire, 2009). It can be noticed an altitudinal segregation, both between and within sexes in the several regions of Europe where adult males are disproportionately abundant at a higher altitude, while females are restricted to la lower altitude (Leuzinger & Brossard, 1994; Russo, 2002).

In Italy, the species has been captured up to 1143 meters of altitude on the Apennines in Abruzzo (Issartel, 2001), while has been captured up to 1665 meters on the Alps in the Gran Paradiso National Park (Patriarca et al., 2016). Data on echolocation calls have been documented up to 1900 meters in the Marittime Alps (Toffoli et al., 2016). A subfossilized skull of the species was found in a cave at 1940 meters on the Ligurian Alps (Lanza, 2012).

On the French side of the Western Alps, the species presence is reported up to 2450 meters in the department Alpes de Haute Provence (Drousie & Cosson, 2016), at 2100 meters in Haute Alpes (Parc National des Ecrins and le Centre de Recherches Alpin sur les Vertebres, 1995) and at 1936 meters in the Rhone-Alpes region (Groupe Chiroptères de la LPO Rhone-Alpes, 2014). For all these records,

however, it is not specified whether it was a capture or an echolocation call survey leading to a consequent uncertainty of the data. Furthermore, the echolocation data cannot determine the sex, considering the different altitude segregation between males and females (Russo, 2002).

This short note contains capture records of *M. daubentoni* on the Western Italian Alps above 1800 meters.

MATERIAL AND METHODS

Some bats were captured in the alpine area of Piedmont (North West Italy) (Fig. 1) with nylon mist-nets with a mesh size between 16 and 19 mm (Agnelli et al., 2004). Mist-nets were placed along flight paths, foraging areas, water bodies and near underground sites. All the nets were checked every 10 minutes and any captured bat was immediately put in cloth bags awaiting to be examined for species identification and biometric measurements. Before release, the bats have been marked with a non-toxic paint. If recaptured, they have been immediately released to minimize stress and avoid double counting. Species identification was carried out according to Dietz & Helversen (2004).

It was possible to classify individuals as juveniles, immature or adults by examining the degree of calcification of the phalanx epiphyses (Dietz & Helversen, 2004). Females were further classified as lactating and not lactating, based on the nipples conditions. Males were classified based on the development of their buccal glands and the degree of swelling of epididymis and testes (Haarsma, 2008).

All animals captured were always released within few minutes to minimize stress. The captures have been carried out with the permission of the Italian Ministry of the Environment (Refs. DPN/2008/0001053; DPN/ 2010/0011879; 000882/ PNM/08052014).

RESULTS

Between 2009 and 2016, five *M. daubentoni* were captured at an altitude above 1800 meters during bat surveys on the Italian Western Alpine region (Table 1). Three captures involved male in foraging activities in alpine wetlands in the SCI IT1140016 (Alpi Veglia Devero-Monte Giove) on the Lepontine Alps at 1828 and 2050 meters of altitude respectively. Two referred to females in swarming

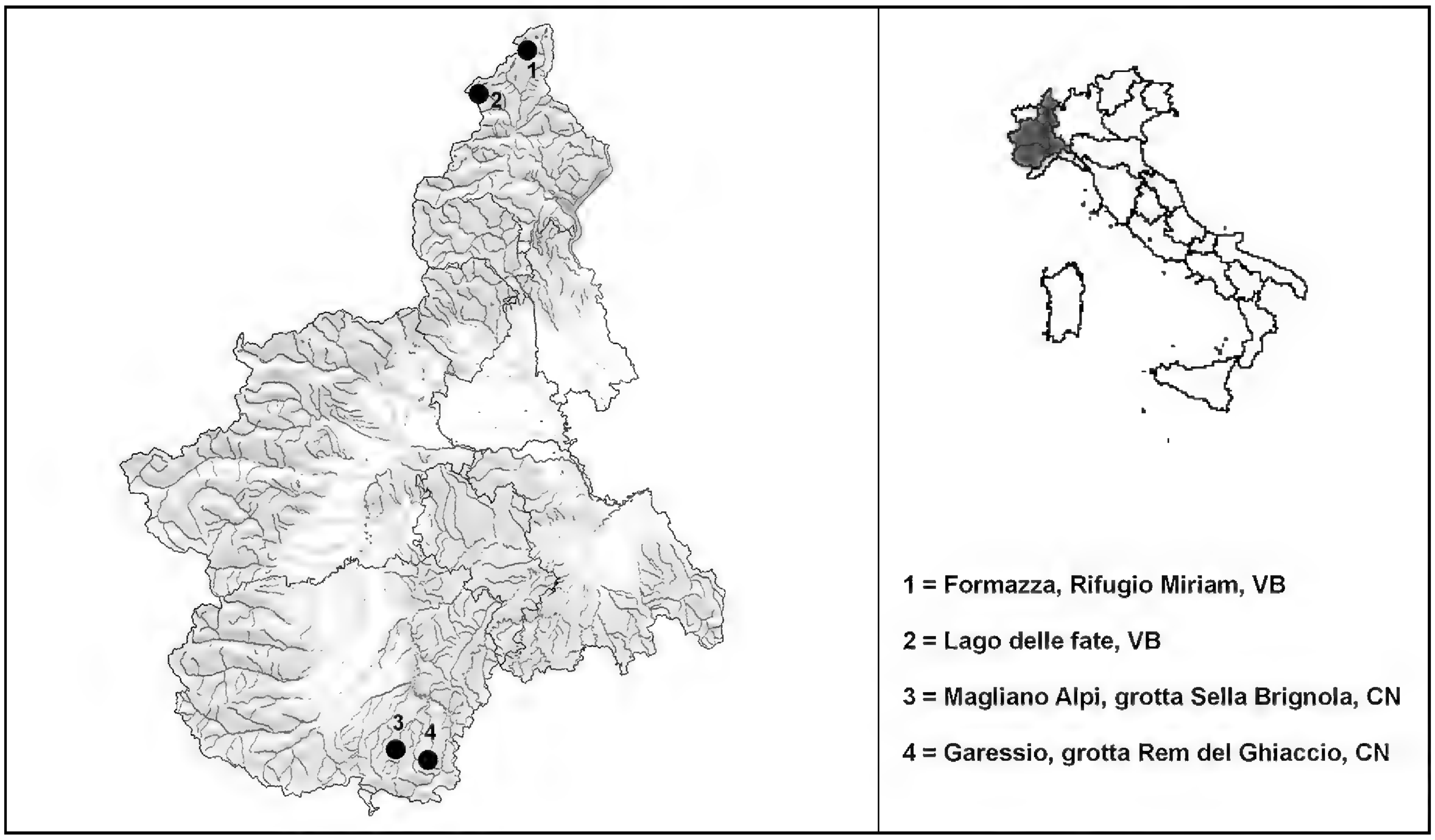

Figure 1. Location of capture of *Myotis daubentonii* in the Italian Western Alps.

ID Place	Place	Date	Activity	Sex	Age	Foream mm	5 finger mm	Body mass gr	Elevation
1	Formazza, Rifugio Miriam, VB	05/08/2009	foraging	Male	Immature	37.53	47.0	7.5	2,050
2	Varzo, Lago delle Fate, VB	20/08/2010	foraging	Male	Adult	36.91	46.5	7.5	1,828
2	Varzo, Lago delle Fate, VB	20/08/2010	foraging	Male	Adult	37.62	47.5	7.6	1,828
3	Magliano Alpi, grotta Sella Brignola, CN	28/08/2016	swarming	Female	Immature	35.84	45.5	7.5	2,022
4	Garessio, grotta Rem del Ghiaccio, CN	20/09/2016	swarming	Female	Adult	37.87	49.5	11.1	1,946

Table 1. Locality, altitude and measures of *Myotis daubentonii* captured in the Italian Western Alps.

Figure 2. An immature male of *Myotis daubentonii* captured at 2050 meters of altitude in Lepontine Alps (Formazza, Rifugio Miryam, VB), 5.VIII.2009.

sites on the Maritime Alps at 1946 metres and 2022 meters above sea level.

All captures took place during the post-reproductive period between August and the second half of September.

DISCUSSION

Data confirm the presence of *M. daubentonii* above 1800 meters up to over 2000 meters of altitude on the Italian Western Alps for both sexes. An immature male was captured during foraging activity in alpine wetlands at an altitude of 2050 meters above sea level (Fig. 2), resulting in the altitude record for this species in Italy. This altitude record exceeds all the previous ones, namely, a capture at 1640 meters above sea level in the Gran Paradiso National Park (Patriarca et al., 2016), some echolocation calls records at 1900 meters of altitude in the Maritime Alps (Toffoli et al., 2016) and the finding of a subfossilized skull of the species in a cave at 1940 meters of height on the Ligurian Alps (Lanza, 2012).

These observations confirm the foraging activity of *M. daubentoni* males at high altitude similarly to what observed on the Apennines in central Italy (Russo, 2002).

The captures of the two female individuals in two swarming sites at 1946 and 2022 meters of altitude respectively are of particular interest. These altitude are significantly higher compared to what observed on the Appennines in central Italy, where female individuals have never been captured over 970 meters of altitude (Russo, 2002). However, in other European mountainous areas such as the Carpathians, no differences were observed between sexes distribution in *M. daubentonii*, as swarming sites and females have been reported up to 1907 meters of altitude (Piksa et al., 2011).

The data presented here represent the highest altitude records for *M. daubentonii* on the Italian Alps, even if they do not reach the altitudes observed on the French side where this species is reported up to 2450 meters above sea level (Drousie & Cosson, 2016). It is still unclear whether these data were the result of a capture or an echolocation call record. However, it should be considered that the climate of the two side of the Western Alps present some differences, with the average temperatures being lower at equal altitude on the Italian side compared to the French side (Bartaletti, 2004),

resulting in a possible presence of the species at different heights.

Further investigations are needed to verify the presence of the species in foraging or swarming activities at an altitude higher than those reported here for the Italian side of the Alps.

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REFERENCES

Agnelli P., Martinoli A., Patriarca E., Russo D., Scaravelli D. & Genovesi P., 2004. Linee Guida per il monitoraggio dei Chirotteri: indicazioni metodologiche per lo studio e la conservazione dei pipistrelli in Italia. Quaderni di Conservazione della Natura, Ministero Ambiente - Istituto Nazionale Fauna Selvatica, 19: 216 pp.

Ahlén I. & Gerell R., 1989. Distribution and status of bats in Sweden. In: Hanák V., Horáček I. & Gaisler J., 1989 (Eds.), European Bat Research 1987. Charles Univeristy Press, Praha, 319–325.

Arthur L. & Lemaire M., 2009. Les Chauves-souris de France Belgique Luxembourg et Suisse. Biotope Edition, 544 pp.

Bartaletti F., 2004. Geografia e cultura delle Alpi. Franco Angeli Ed., 225 pp.

Bogdarina S.V. & Strelkov P., 2003. Distribution of bats (Chiroptera) in the north of European Russia. Plecotus, 6: 7–28.

Dietz C. & Helversen O. von, 2004. Illustrated identification key to the bats of Europe. Electronic Publication Version 1.0. Released 15.12.2004. Tuebingen & Erlangen, Germany, 72 pp.

Dietz C. & Kiefer A., 2016. Bats of Britain and Europe. Bloomsbury Publishing, 399 pp.

Drousie M. & Cosson M., 2016. Le vespertilion de Daubenton *Myotis daubentoni*. In: LPO, PACA, GECEM & GCP 2016, Les Mammifères de Provence-Cote d'Azur. Biotope, Mèze: 156–157.

Groupe Chiroptères de la LPO Rhone-Alpes, 2014. Les chauves souris de Rhone-Alpes. LPO Rhone-Alpes, Lyon, 478 pp.

Haarsma A.J., 2008. Manual for assessment of reproductive status, age and health in european vespertilionid bats. Electronic publication, first released 12.09.2008. Hillegom, Holland.

Helversen O. von & Weid R., 1990. Die Verbreitung einiger Fledermausarten in Griechenland. Bonner Zoologische Beiträge, 41: 9–22.

Jones G. & Rayner J.M.V., 1988. Flight performance, foraging tactics and echolocation in free-living Daubenton's bats *Myotis daubentoni* (Chiroptera: Vespertilionidae). Journal of Zoology, 215: 113–132.

Kalko E.K.V. & Schnitzler H.U., 1989. The echolocation and hunting behaviour of Daubenton's bat, *Myotis daubentonii*. Behavioral ecology and sociobiology, 24: 225–238.

Issartel G., 2001. Inventaire des chiropteres du Parc national des Abruzzes (Italie). Le Rhinolophe, 15: 141–156.

Lanza B., 2012. Fauna d'Italia. Mammalia V. Chiroptera. Calderini Editore, Bologna, 47, 789 pp.

Leuzinger Y. & Brossard C., 1994. Repartition de *M. daubentonii* en fonction du sexes et de la periode de l'annee dans le Jura Bernois. Mitteilungen der Naturforschenden Gesellschaft Schaffhausen, 39: 135.

Parc National des Ecrins and le Centre de Recherches Alpin sur les Vertebres, 1995. Faune sauvage des Alpes du Haut-Dauphine. Atlas des Vertebres. Tome I, Parc National des Ecrins and le Centre de Recherches Alpin sur les Vertebres, 303 pp.

Patriarca E., Debernardi P. & Garzoli L., 2016. The bats of Gran Paradiso National Park: inventory and preliminary characterization of distribution, with evidence of the influence of artificial lighting. In: Chirichella R., Imperio S., Molinari A., Sozio G., Mazzaracca S. & Preatoni D.G. (Eds.) 2016, X Congresso Nazionale di Teriologia. Hystrix, the Italian Journal of Mammalogy 27 (Supplement): 129.

Piksa K., Bogdanowicz W. & Tereba A., 2011. Swarming of bats at different elevations in the Carpathian Mountains. Acta Chiropterologica, 13, 113–122.

Russo D., 2002. Elevation affects the distribution of the two sexes in Daubenton's bats *Myotis daubentonii* (Chiroptera: Vespertilionidae) from Italy. Mammalia, 66: 543–551.

Toffoli R., Culasso P., Locatelli A.G. & Giraudo L., 2016. Bats of Alpi Marittime Nature Park (North West Italy) and Site of Community Importance IT1160056: distribution and status. Natural History Sciences, 3: 3–13.

Vaughan N., Jones G. & Harris S., 1997. Habitat use by bats (Chiroptera) assessed by means of a broad-band acoustic method. Journal of Applied Ecology, 34: 716–730.

Warren R.D., Waters D.A., Altringham J.D. & Bullock D.J., 2000. The distribution of Daubenton's bats (*Myotis daubentonii*) and pipistrelle bats (*Pipistrellus pipistrellus*) (Vespertilionidae) in relation to small-scale variation in riverine habitat. Biological Conservation, 92: 85–91.

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Discovery of some white quills of the crested porcupine *Hystrix cristata* (Linnaeus, 1758) (Mammalia Rodentia)

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ABSTRACT In this note, we report the discovery of some white quills belonging to the crested porcupine *Hystrix cristata* Linnaeus, 1758 (Mammalia Rodentia) from Sabini Mountains (Central Italy). We hypothesize the leucism of the individual.

KEY WORDS Leucism; Albinism; Crested porcupine; *Hystrix cristata*; Monti Sabini; Central Italy.

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INTRODUCTION

Albinism is a genetic condition caused by an autosomal recessive gene that affects normal pigmentation in humans and animals (Oliveira & Foresti, 1996) and is characterized by the absence of pigment in the eyes, skin, hair, scales, feathers, or cuticles. These phenomena may be related to environmental factors, such as exposure to heavy metals (Oliveira & Foresti, 1996), heredity (Ueda et al., 2007), or artificial selection of albino individuals in captivity. The total albinism can occur in all vertebrates groups and it is characterized by whitish body and the presence of red eyes (Sazima & Pombal, 1986). On the contrary, partial albinism, also known as leucism, is characterized by presence of pigmentation in only some parts of the body - e.g. the eyes - that are not pink as in the albins (Lutz, 2001).

Albinism in mammals is a known and fairly common phenomenon (Jones, 1920; Caro, 2005). In the case of *Hystrix cristata* Linnaeus, 1758 (Mammalia Rodentia), there are no observations of albino or leucistic individuals in nature apart from the citation relating to the *Hystrix africae australis* Peters, 1852, in the territory of Ex-Rhodesia (today Zimbabwe), captured close to Chiredzi River, and kept at the National Museum of Bulawayo (Mohr, 1965). The only known albino individuals of *H. cristata* are bred in captivity by private breeders and / or by the Olmen Zoo in Belgium (http://www.chiangmainightsafari.com/cnsweb/index.php/en/animals-type/85-jajuar/160-albino-crested-porcupine; https://www.youtube.com/watch?v=sqykj0_ 6BqA). Obviously, albino individuals are unfavorably selected and their life expectancy in nature would seem very low, either by low vitality, great sensibility to sunlight, difficulty in intraspecific interactions, or by a clear disadvantage respect to predators (McCardle, 2012). The specimens suffering from leucism, which can be considered as a low level of partial albinism, don't have red eyes, and the individual is neither weak nor particularly sensitive to sunlight and heat (McCardle, 2012).

MATERIAL AND METHODS

Study area

The Sabini Mountains are located to the west by the Tevere River, to the north by the Nera River, to the east by the Velino River and the Turano River, and to the south by the Aniene River. The Tancia Mount with 1282 meters a.s.l. is the highest peak of the Sabini Mountains. They are made up of a northern section, the Sabini Mountains, located near the border between Latium and Umbria, and the southern section, the Lucretili Mountains, on the border between the province of Rieti and the province of Rome. The two subgroups are divided by the flat and hilly territories of Sabina. These are young reliefs, from the composition of marl and limestone. Due to the action of the weather agents and the dense woody vegetation, these territories have been of little use to the man. Only relatively recently, these territories have suffered heavy deforestation to make way for farming and agriculture. In the massif of Tancia, there are two main plant landscapes: the thermophilic and heliophilous of the southern slope and the mesophilic of the northern and eastern sides. In the southern slope, there are, in fact, vegetable species that prefer warmer temperatures such as *Quercus ilex* L., *Pistacia lentiscus* L., *P. terebinthus* L., *Smilax aspera* L. and *Cercis siliquastrum* L. At higher altitudes, there are *Q. cerris* L., *Q. pubescens* Willd. and other mixed stains. On the northern slope, at higher altitudes, there is *Fagus sylvatica* L. In addition to *Hystrix cristata*, in the area there are also other wild mammals like *Sus scrofa* Linnaeus, 1758, *Capreolus capreolus* Linnaeus, 1758, *Meles meles* Linnaeus, 1758, *Felis silvestris* Schreber, 1777, *Sciurus vulgaris* Linnaeus, 1758, *Canis lupus* Linnaeus, 1758, *Martes martes* Linnaeus, 1758, *M. foina* Erxleben, 1777, *Mustela nivalis* Linnaeus, 1758, *M. putorius* (Linnaeus, 1758), and *Erinaceus europaeus* Linnaeus, 1758.

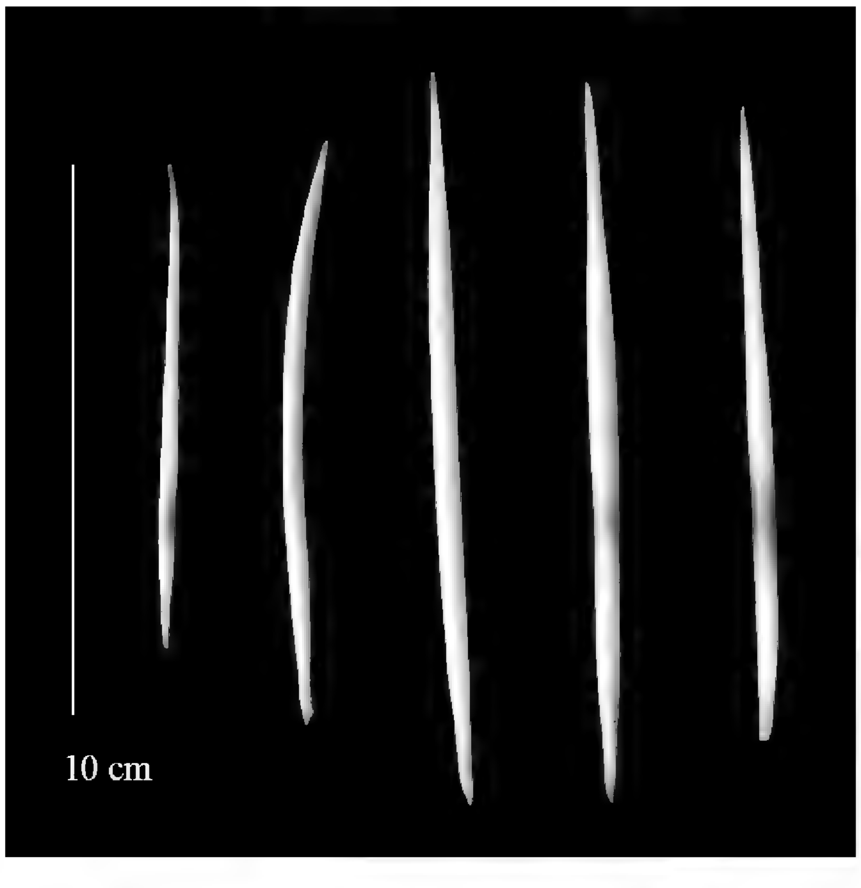

Figure 1. White quills of the crested porcupine *Hystrix cristata* from Sabini Mountains (Central Italy).

Methods

In November 2016, one of the authors (M.G.) found five whitish quills of crested porcupine, almost completely white, without the characteristic black rings (Fig. 1). All quills have been found in an area of about two meters and are very likely to belong to the same individual. The location of the discovery is a mountain trail (678 m a.s.l., 42°18'18.98"N, 12°43'59,02"E) leading to the summit of Mount Tancia. This area is in the municipality of Monte San Giovanni in Sabina, in the province of Rieti (Latium, Central Italy).

RESULTS AND CONCLUSIONS

The quills found were in good conditions and they are those of the upper part and appear to belong to a young individual (Fig. 1). It does not seem that the quills have belonged to a prey, considering that none of them was broken. They were probably lost by the individual in transit at the place of discovery. Looking carefully, it is possible to notice the presence of mild brown pigment residues, which lead to think that the individual was probably suffering from leucism, or a partial form of albinism rather than real albinism. It would be interesting to know whether the leucistic porcupines are disadvantaged or not in regard to predation, and intraspecific interactions. Concerning the anti-predatory defense mechanisms, at least in Italy, it can only be reasonably assumed that the porcupine is able to defend itself, as represented by the quills themselves.

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REFERENCES

Caro T., 2005. The adaptive significance of coloration in mammals. Bioscience, 55: 125–136.

Jones S.V.H., 1920. Color variations in wild animals. Journal of Mammalogy, 4: 172–177.

Lutz C.G., 2001. Practical genetics for aquaculture. Blackwell Science, Oxford, 222 pp.

McCardle H., 2012. Albinism in wild vertebrates. Master Thesis, Texas State University - San Marcos, 82 pp.

Mohr E., 1965. Altweltliche Stachelschweine. A. Ziemsen Verlag, Wittenberg Lutherstadt, 164 pp.

Oliveira C. & Foresti F., 1996. Albinism in the banded knifefisch *Gymnotus carapo*. TFH Magazine, 44: 92–96.

Sazima I. & Pombal J.P., 1986. Um albino de *Rhamdella minuta*, com notas sobre comportamento (Osteichthyes, Pimelodidae). Revista Brasileira de Biologia, 46: 377–381.

Ueda T., Ishinabe T. & Jeon S.R., 2007. Establishment of an albino strain of the bitterling *Tanakia signifer* (Pisces, Cyprinidae). Journal of Heredity, 98: 277–279.

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Effect of parasitism on the length/weight relationship and the condition index in two groups of *Pagellus acarne* (Risso, 1826) (Perciformes Sparidae), parasitized and unparasitized specimens, from the Eastern Coast of Algeria

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ABSTRACT

In the present study, the relationship between parasitism and some host biological parameters is studied for the first time in *Pagellus acarne* (Risso, 1826) (Perciformes Sparidae) from the eastern coast of Algeria. This study is carried out on 111 specimens, examined between April 2013 and March 2014. Parasitofauna of *P. acarne* is rich and various; 373 parasites belonging to different parasite groups are reported. Eleven parasite species are identified: 3 Digenea, 1 Isopoda, 3 Monogenea and 4 Nematoda, with the predominance of Nematoda (more than 50%). Our results reveal that mean intensity increases with the length of the host and varies from 4 to 8 parasites by infested host. The comparison of some biological parameters (length/weight relationship and the Fulton condition index K) does not show significant differences between parasitized and unparasitized specimens. These results allow us to deduct that *P. acarne* from the eastern cost of Algeria is not affected by parasitism despite the important parasite infestation.

KEY WORDS Parasites; *Pagellus acarne*; biological parameters; Eastern Algeria.

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INTRODUCTION

In contrast to free-living organisms, parasites are characterized by the fact that they are lodged in the host biotope; therefore, this relationship requires some conditions in which the host fish represents both; the biotope and the food source of the parasite, thus maintaining the equilibrium of the marine ecosystem (Euzet & Combes, 1980).

In the Mediterranean, several authors have reported numerous economic losses due to teleost fishes caused by the pathogenic effect of ectoparasites (Ben Hassine et al., 1990; Ben Cheikh, 1993; Ben Cheikh et al., 1994; Faliex & Morand, 1994; Sasal et al., 1996; Ramdane, 2009); for example, Isopod Gnathidae are haematophagous ectoparasites causing perforations in the host tissues and therefore lesions that would represent pathways to viruses and bacteria (Cohen & Poore, 1994; Bunkley et al., 2006; Tanaka & Nishi, 2008), so parasitism can have a series of stress and disturbances over the life cycle of fish (Bobadilla, 2009; Ferrer-Maza et al., 2014); recently, Ichalal et al. (2016) reported that nematodes induced intersexuality in females of *Trachurus trachurus* (Linnaeus, 1758).

Pagellus acarne (Risso, 1826) (Perciformes

Sparidae) is widespread in the Mediterranean Sea, Europe, Africa and the Black Sea; on the Algerian coast at depths up to 520 meters (Refes, 2011), despite the economic importance of this species, the studies devoted to its parasitofauna in Algeria have not exceeded the group of ectoparasites which was carried out by (Ramdane et al., 2009; Kaouachi et al., 2010; Boualeg et al., 2012). The objective of this article is to clarify the hypothesis concerning the effect of parasitism on the biological performances of *P. acarne* from the eastern cost of Algeria.

MATERIAL AND METHODS

Our study was carried out on one hundred and eleven axillary Seabream which were sampled (randomly, depending on the availability of the species), between April 2013 and March 2014 from the commercial fishing vessels; from the Gulf of Bejaia, in the eastern coast of Algeria, the fish are examined in the spawning state; the total length (Lt) and the total weight (Wt) of each fish were measured using an ichthyometer (0.5 cm accuracy) and an electronic balance (0.1mg accuracy) so the parasitological study was made for each fish in order to collect all the existing parasites. To do that, we examined the surface of the fish thoroughly first with the naked eye and after under a magnifying glass with stereomicroscope for a rapid identification of the ectoparasites and to dissect immediate of the fish; once the meso-parasites were collected, they were cleaned and fixed in 70% Ethanol (for subsequent identification). In order to assess parasitism on *P. acarne,* we calculated the population descriptors namely: prevalence, mean intensity and abundance as proposed by Bush et al. (1997) and Margolis et al. (1982), and also the condition index K: $K = (W)/Lt^b$ (W: weight, L: length b: allometric coefficient considered as equal to 3) (Sutton et al., 2000), in order to compare the muscle reserves of the two groups of *P. acarne* (parasitized and unparasitized) and concerning the comparison in length/weight relationship between parasitized and unparasitized specimens the values of the constants a = intercept, b = slope (of the length-weight relationship) "a" and "b"of the linear regression of the length/weight relationship ($\log W = b \log L + \log a$) were calculated. The slopes of the equations were compared using a covariance analysis (ANCOVA) (variable used: length (cm) and weight (g)) made with the "XLSTAT" (2016) software.

RESULTS AND DISCUSSION

Parasitic diversity

We have collected 373 parasites, the prevalence of the different groups of parasites reveals the predominance of the Nematoda group (P= 50.45%). We report in this article some species of parasites, identified on the *P. acarne* from the gulf of Bejaia: *Hysterothylacium fabri* (Rudolphi, 1819), *Hystrothylacium* sp., *Cucullanus* sp., and *Ascarophis* sp.; the predominance of the Nematoda has already been reported from Suez Canal area with (P=60%), but the species identified differ from those reported in Suez Canal area (Egypt) (Eissa et al., 2012), followed by Monogenea (P= 29.72%) (*Lamellodiscus drummondi* Euzet et Oliver, 1967 *Atrispinum acarne* (Maillard et Noisy, 1979), *Choricothyle chrysophrii* (Monticelli, 1888)) which is also reported in the Mediterranean Sea (Maillard & Noisy, 1979) and in Algeria by Kaouachi et al. (2010) then the Tetraphyllidae larvae and Isopoda: (*Gnathia* sp.) with a prevalence of 17.11%, the Isopoda group has been reported too in the eastern cost of Algeria by Ramdane et al. (2009) and Boualeg et al. (2012), then Digenea group (P= 8.10%) (*Derogenes latus* Janiszewska, 1953, *Lepocreadium album* Stossich, 1904 and *Pycnadenoides senegalensis* Fischthal et Thomas, 1972; the different species of the Nematoda and Digenea fauna are reported for the first time in *P. acarne* from the eastern coast of Algeria. and finally Acanthocephala (P= 6.3%) (Fig.1). It emerges from this study that *P. acarne* from the Gulf of Bejaia hosts a very diverse parasitic fauna, this groups have already been reported in the North East Atlantic by Petter & Cabaret (1995), in the North Atlantic Moroccan's Waters (Azbaid et al., 2016) and in the Mediterranean sea by several authors (Bray & Cribb, 1997; Sasal et al., 1997).

Parasitological indexes

Our results on parasitological indexes (Figs. 2, 3) show that the specimens with a high length of this fish are the most infested, the abundance and the prevalence increases with the growth in length

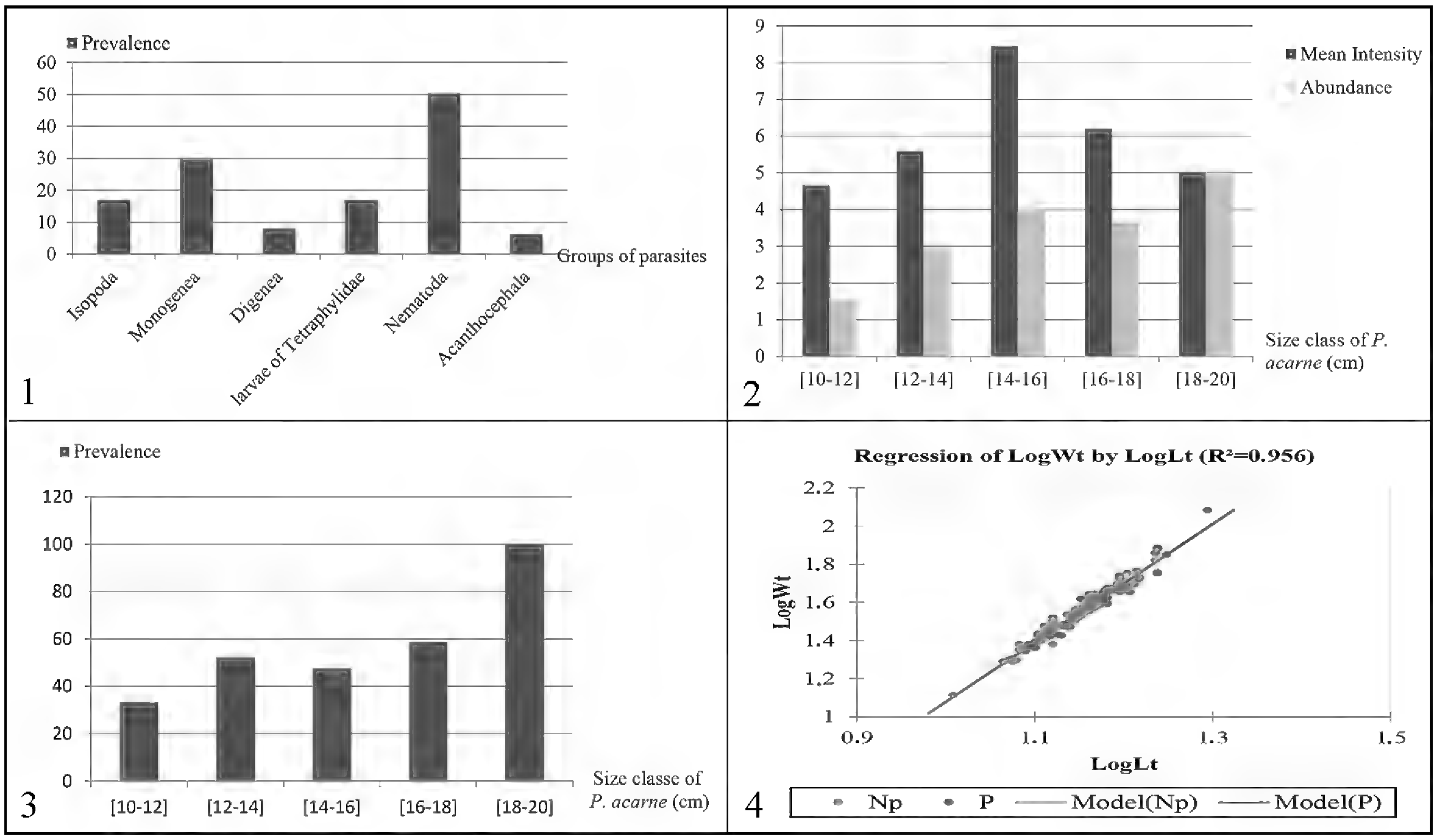

Figure 1. Prevalence (%) of *Pagellus acarne* parasites from the Gulf of Bejaia. Figure 2. Variation of parasitological indexes (mean intensity and abundance) according to size class of *Pagellus acarne*. Figure 3. Variation of prevalence (%) according to size class of *Pagellus acarne*. Figure 4. Regression of Log weight by Log length of the (P) parasitized and (Np) unparasitized specimens of *Pagellus acarne*, R^2: correlation coefficient.

of the fish; abundance varies from 1 to 5 parasites by fish, whereas mean Intensity varies from 4 to 8 parasites by infested fish. Parasitic loads seem to increase with specimen's length. Our findings corroborate with those of Azbaid et al. (2016), Lo et al. (1998) and Machado et al. (1994) who showed clearly that the level of parasitism increases over the host size development.

The condition index of Fulton K

This index characterizes nutritional status and energy reserves of the fish (Table 1). K does not show any significant difference between parasitized and unparasitized *P. acarne* (ANOVA, P= 0.388 >0.05). This was confirmed in *Mullus barbatus barbatus* (Linnaeus, 1758) by Ramdane et al. (2010), whose condition index was not affected despite the large infestation by various parasites species. It seems that parasitized fish increase their energy gain by feeding more than unparasitized specimens to compensate for their losses; accord-ing to Östlund-Nilsson et al. (2005), host develops strategies to overcome the corresponding energy losses (form of adaptation developed by the host).

The relationship length/weight

The results obtained from the study of the length/weight relationship (Fig. 4) show a good correlation between the length and weight of the two groups of *P. acarne* (parasitized and unparasitized) r^2=0.955: so both groups keep the same normal general form with a good correlation without any difference, whether parasitized or not. Statistical analysis did not show any significant difference (ANCOVA, p= 0.481> 0.0001) and, in the Mediterranean Sea, different research for the exponential relationship between the length and weight of the axillary Seabream indicates that «b» change from one locality to another and varies from 2.086 to 3.281 (Table 2). This difference is related to the ecological niche of the species (geographical position and ecological conditions of the biotope like upwelling, salinity, temperature…). It also has relationship with fish biology: age, sex, length, fish diet, etc. (Ricker, 1975; Bagenal & Tesch, 1978; So-

marakis & Machias, 2002). Our results are included in this range but unparasitized groups have an isometric growth (b= 3.0) while the parasitized groups have an upper bound allometry (b= 3.19>3). The difference between the two groups of *P. acarne* cannot be linked to the presence of parasites; according to Rameshkumar et al. (2014), the presence of a parasite in the marine environment does not always mean the occurrence disorders in the fish especially in the case of a wild fish and we noticed predominance of: size class (11–15), indeterminate sex and male sex in the group of non-infested *P. acarne*, which explains the difference, Özaydın & Taskavak (2006), Özaydın et al. (2007) and Sangun et al. (2007) have found a lower result than ours. Dorel (1986) explains that a fish of undetermined sex generally exhibit isometric growth as long as these specimens have not yet reached their sexual maturity so the presence of parasite did not induce any effect on the length/weight relationship of the *P. acarne,* especially that isometric growth that has already been reported in this fish species in several Mediterranean research and also in the western Algerian coastline (Bensahla Talet et al., 2009). In addition to, research conducted in the northeast Mediterranean Sea by Genc (2007) suggests that Gnathiid parasites have no effect on the growth and general health condition of infested *Epinephelus marginatus* (Lowe, 1834), despite the high parasitic infestation; in Hajji et al. (1994), the authors also reported the lack of difference between the length/weight relationships in the two groups of sardine.

Specimens examined	N	K±SD	p
Parasitized specimens	56	1.24±0.09	P=0.38> 0.05
Unparasitized specimens	55	1.25±0.08	

Table 1. Variation of the condition index (K) (g.cm-3) between parasitized and unparasitized specimens. N: number of *Pagellus acarne*, SD: standard deviation, P: ANOVA test

Site		Type of fish	n	a	b	r^2	Authors
Spain The *Canary Islands*		M	556	0.0065	3.242	0.98	(Pajuelo & Lorenzo, 2000)
		F	968	0.0062	3.281	0.99	
Turkey	Mediterranean Sea	C	83	0.0186	2.841	0.91	(Sangun et al., 2007)
		C	901	0.0075	3.15	0.95	(Cicek et al., 2006)
	Aegean Sea	C	335	0.0942	2.086	0.95	(Özaydın & Taskavak, 2006)
		C	303	0.0302	2.782	0.963	(Özaydın et al., 2007)
		C	334	0.0104	3.06	0.93	(Ilkyaz et al., 2008)
		C	46	0.0088	3.112	0.952	(Ceyhan et al., 2009)
France Bay of Biscay		Ind	257	0.086	3.131	0.994	(Dorel, 1986)
Algeria	Bay of Oran	C	850	0.0089	3.10	0.959	(Bensahla Talet et al., 2009)
		M	271	0.0093	3.08	0.969	
		F	306	0.0111	3.03	0.969	
	Gulf of Bejaia	P	56	0.007	3.19	0.956	Present
		UNP	55	0.012	3	0.953	Work

Table. 2. Parameters of the length-weight relationship [weight (in g) and length (in cm)] of *Pagellus acarne* in different regions of the Mediterranean Sea; n; number of *P. acarne*, a: allometric coefficient, b: slope of the regression line, r^2: coefficient of correlation M: male, F: female, C: combined, Ind: indeterminate sex, P: parasitized fish, NP: unparasitized fish.

CONCLUSIONS

It emerges from this study that *P. acarne* of the eastern cost of Algeria harbors a very diverse parasitic fauna, with a dominance of the group of Nematoda. Size class 18–20 cm is more infested by various systematic groups. The parasitism has no effect on the biological performance of *P. acarne* despite the important parasite infestation. This may probably be due to the adaptation of the host to the presence of the parasite.

REFERENCES

Azbaid L., Belcaid S. & Talbaoui M., 2016. Anisakid Nematodes of *Pagellus acarne* and *Trachurus trachurus*, from North Atlantic Moroccan's Waters Journal of Life Sciences 279–288.

Bagenal T.P. & Tesch F.W., 1978. Age and Growth. In: T.B. Bagenal (Ed.), Methods for Assessment of Fish production in Freshwater. 3rd ed. IBP Handbook, Blackwell, Oxford, pp. 93–130.

Bartoli P., Gibson I.D., Bray A.R., Maillard C. & Lambert M., 1989. The Opecoelidae (Digenea) of sparid fishes of the western Mediterranean. II. *Pycnadenoides* Yamaguti, 1938 and *Pseudopycnadena* Saad Fares & Maillard, 1986. Systematic Parasitology, 13: 35– 51.

Ben Cheikh S., 1993. Contribution à l'étude de *Peroderma cylindricum* Heller, 7865, parasite de la sardine, *Sardina pilchardus* (Walbaum, 1792) des côtes tunisiennes. DEA, 91 p. Faculté des Sciences de Tunis.

Ben Cheikh S., Raibaut A., Euzet S. & Ben Hassine O.K., 1994. Etude biosystémique de deux populations de téléostéens (*Sardina pilchardus*) et de leurs copépodes parasites (*Peroderma cylindricurn*) sur les côtes tunisiennes. Parasite, 1: 279– 282.

Ben Hassine O.K., Raibaut A., Ben Souissi J. & Rousset V., 1990. Morphologie de *Peroderma cylindricum* Heller, 1865, copépode parasite de la sardine, *Sardina pilchardus* (Walbaum, 1792) et quelques aspects de son écologie dans les eaux côtières tunisiennes. Annales des sciences naturelles, 11: 9– 16.

Bensahla Talet L., Abi Ayad S.M.A., Kerfouf S.A., Boutiba Z. & Bensahla Talet A., 2009. Paramètres de la croissance relative et absolue de (*Pagellus acarne* Risso, 1826) des eaux oranaises Bulletin de l'Institut National des Sciences et Technologies de la Mer (I.N.S.T.M. Salammbô). Actes des Onzièmes Journées Tunisiennes des Sciences de la Mer (Nabeul TUNISIE 19–22 décembre 2009), Numéro Spécial 14: 66–69.

Bobadilla A.S., 2009. Can myxosporean parasites compromise fish and amphibian reproduction? Proceedings of the Royal Society of London B, 276: 2861–2870.

Boualeg C., Kaouachi N. & Bensouilah M., 2012. L'infestation de douze espèces de Sparidae par le parasite *Gnathia* sp. (Isopoda: Gnathiidae) dans le littoral est-algérien. Bulletin de l'Institut Scientifique, Rabat, section Sciences de la vie, 34: 65–70.

Bray R.A. & Cribb T.H., 1997. The subfamily Aephnidiogeninae Yamaguti, 1934 (Digenea: Lepocreadiidae), its status and that of the genera *Aephnidiogenes* Nicoll, 1915, *Holorchis* Stossich, 1901, *Austroholorchis* n. g., *Pseudaephnidiogenes* Yamaguti, 1971, *Pseudoholorchis* Yamaguti, 1958 and *Neolepocreadium* Thomas, 1960. Systematic Parasitology, 36: 47–68.

Bush A.O., Lafferty K.D., Lotz J.M. & Shostak A.W., 1997. Parasitology meets ecology on its own terms: Margolis et al. Revisited. Journal of Parasitology, 83: 575–583.

Bunkley W.L., Williams E.H. & Bashirullah A.K.M., 2006. Isopods (Isopoda: Aegidae, Cymothoidae, Gnathiidae) associated with Venezuelan marine fishes (Elasmobranchii, Actinopterygii). Revista De Biologia Tropical, 54: 175–188.

Ceyhan T., Akyol O 1. & Eerdem M., 2009. Length-Weight Relationships of Fishes from Gökova Bay, Turkey (Aegean Sea) Turkish Journal of Zoology, 33: 69–72.

Cicek E., Avsar D., Yeldan H. & Ozutok M., 2006. Length–weight relationships for 31 teleost fishes caught by bottom trawl net in the Babadillimani Bight (northeastern Mediterranean). Journal of Applied Ichthyology, 22: 290–292. DOI: 10.1111/j.1439-0426.2006.00755.x.

Cohen B.F. & Poore G.C.B., 1994. Phylogeny and biogeography of the Gnathiidae (Crustacea: Isopoda) with descriptions of new genera and species, most from south-eastern Australia. Memoirs of Museum Victoria, 54, 271–397.

Dorel D., 1986. Poissons de l'Atlantique nord-est relations taille-poids. Institut Français de Recherche pour l'Exploitation de la Mer. Nantes, France, 165 pp.

Eissa I.A.M., Mona A.E., El-Genidy H.M. & El-Fatah W.A.A., 2012. Studies on prevailing nematodiasis in marine fish *Pagellus acarne* in Suez, Egypt. Global Journal of Fisheries and Aquaculture Researches, 5: 58–70.

Euzet L. & Combes C., 1980. Les problèmes de l'espèce chez les animaux parasites. Mémoires de la Société Zoologique de France, 40: 239–285.

Faliex E. & Morand S., 1994. Population dynamics of the metacercarialstage of the bucephalid trematode, *Labatrema minimus* (Stossich, 1887) from Salses-Leucate lagoon (France) during the cercarial shedding period. Journal of Helminthology, 168: 35–40.

Ferrer-Maza D., Lloret J., Munoz M., Faliex E., Vila S. & Sasal P., 2014. Parasitism, condition and reproduction of the European hake (*Merluccius merluccius*) in the northwestern Mediterranean Sea. ICES Journal of Marine Science, 71: 1088–1099.

Genc E., 2007. Infestation status of gnathiid isopod juveniles parasitic on Dusky grouper (*Epinephelus marginatus*) from the northeast Mediterranean Sea. Parasitology Research, 101: 761–766.

Hajji T., Ben Hassine O.K. & Farrugio H., 1994. Impact du copépode parasite *Peroderma cylíndrícum* Heller, 1868 sur la croissance et la fécondité des stocks exploités de la sardine *Sardina pilchardus* (Walbaum, 1792). CIHEAM Options Méditerranéennes, 79–86.

Ichalal K., Ramdane Z., Iguer-Ouada M. & Kacher M., 2016. First observation of intersex in *Trachurus trachurus* (Carangidae) from the Eastern Coast of Algeria: are nematodes the causative factor? Cybium, 40: 225–233.

Ilkyaz A., Metin G., Soykan O. & Kinacigil H., 2008. Length weight relationship of 62 fish species from the Central Aegean Sea, Turkey. Journal of Applied Ichthyoloy, 23: 699–702.

Kaouachi N., Boualleg C., Bensouilah M. & Marchand B., 2010. Monogenean parasites in Sparid fish (*Pagellus* genus) in eastern Algeria coastline, African Journal of Microbiology Research, 4: 989–993.

Lo C.M., Morand S. & Galzin R., 1998. Parasite diversity/host age and size relationship in three coral-reef fishes from French Polynesia. International Journal for Parasitology, 28: 1695–1708.

Machado M.H., Pavanelli G.C. & Takemoto R.M., 1994. Influence of host's sex and size on endoparasitic infrapopulations of *Pseudoplatystoma corruscans* and *Schizodon borelli* (Osteichthyes) of the high Paraná river, Brazil. Revista Brasileira de Parasitologia Veterinária, 3: 143–148.

Maillard D. & Noisy D., 1979. *Atrispinum acarne* n. g. n.sp. (Monogenea Microcotylidae), parasite de *Pagellus acarne* (Telostei) du Golfe du Lion. Vie et Milieu, 28/29: 579–588.

Margolis L., Esch G.W., Holmes J.C., Kuris A.M. & Schad G.A., 1982. The use of ecological terms in parasitology (report of an ad hoc committee of the American Society of parasitologists). Journal of Parasitology, 68: 131–133.

Östlund-Nilsson S., Curtis L., Goran E.N. & Grutter A.S., 2005. Parasitic isopod *Anilocra apogonae*, a drag for the cardinal fish *Cheilodipterus quinquelineatus*. Marine Ecology Progress Series, 287: 209–216.

Özaydın O. & Taskavak E., 2006. Length-weight relationships for 47 fish species from Izmir Bau eastern Aegean Sea, Turkey. Acta Adriatica, 47: 211.

Özaydın O., Uçkun D., Akalın S., Leblebici S. & Tosunoğlu Z., 2007. Length-weight relationships of fishes captured from Izmir Bay, Central Aegean Sea. Journal of Applied Ichthyology, 23: 695–696.

Pajuelo J G. & Lorenzo J.M., 2000. Reproduction, age, growth and mortality of axillary seabream, *Pagellus acarne* (Sparidae), from the Canarian archipelago. Journal of Applied Ichthyology, 16: 41–47.

Petter A.J. & Cabaret J., 1995. Ascaridoid Nematodes of Teleostean fishes from the eastern North Atlantic and sea of the North of Europe. Parasite, 2: 217–230.

Ramdane Z., 2009. Identification et écologie des ectoparasites Crustacés des poissons Téléostéens de la côte Est algérienne. Thèse de Doctorat, University Badji Moktar, Annaba, 235 pp.

Ramdane Z., Bensouilah M.A. & Trilles JP., 2009. Étude comparative des crustacés isopodes et copépodes ectoparasites de poissons marins algériens et marocains. Cybium, 33: 123–131.

Ramdane Z., Amara R. & Trilles JP., 2010. Impact des parasites sur les performances biologiques de *Mullus barbatus barbatus* L. INOC-Tischreen University, International conference on Biodiversity of the Aquatic Environment, 369–384.

Rameshkumar G., Ravichandran S. & Venmathi Maran B.A., 2014. Occurrence of parasitic copepods in Carangid fishes from Parangipettai, Southeast coast of India. Journal of Parasitic Diseases, 38: 317–323.

Refes W., 2011. Contribution à la connaissance de la biodiversité des fonds chalutables de la côte algérienne: les peuplements ichtyologiques des fonds chalutables du secteur oriental de la côte algérienne. Thèse de Doctorat, Univ. Badji Moktar, Annaba, 280 pp.

Ricker W.E., 1975. Computation and interpretation of biological statistics of fish populations. Bulettin of the Fisheries Research Board of Canada, 191: 1–382.

Sangun L., Akamca E. & Akar M., 2007. Weight-Length Relationships for 39 Fish Species from the North-Eastern Mediterranean Coast of Turkey. Turkish Journal of Fisheries and Aquatic Sciences, 7: 37–40.

Sasal P., Falliex E. & Morand S., 1996. Parasitism of *Gobius bucchichii* Steindachner, 1870 (Teleostei, Gobiidae) in protected and unprotected marine environment. Journal of Wildlife Diseases, 32: 607–613.

Sasal P., Morand S. & Guegan J-F., 1997. Determinants of parasite species richness in Mediterranean marine fishes. Marine Ecology Progress, 149, 61–71.

Sutton S.G., Bult T.P. & Haedrich R., 2000. Relationships among fat weight, body weight, water weight and condition factors in wild Atlantic Salmon Parr. Transactions of the American Fisheries Society, 129: 527–538.

Somarakis S. & Machias A., 2002. Age, Growth and bathymetric distribution of red Pandora (*Pagellus erythrinus*) on the Cretan shelf (eastern Mediterranean). Journal of the Marine Biological Association of the United Kingdom, 82: 149–160.

Tanaka K. & Nishi E., 2008. Habitat use by the gnathiid isopod *Elaphognathia discolor* living in terebellid polychaete tubes. Journal of the Marine Biological Association UK, 88: 57–63.

XLSTAT, 2016. Data Analysis and Statistical Solution for Microsoft Excel. Paris, France.

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Bhutan freshwater gastropods and trematodes, with a warning

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ABSTRACT The freshwater gastropod species that have been recorded in Bhutan are listed in this work. Distributional data for the country are presented and references are given to the original descriptions and to illustrations of the species that may be useful for identification. An identification key is added and shells of all gastropod species are illustrated. We emphasize that some of the freshwater gastropods occurring in Bhutan may act as hosts for trematodes, as is known to be the case in other countries in Asia. These species may cause trematodiases in livestock and humans. Introductory references to the literature on snails and their parasitic trematodes are cited.

KEY WORDS Gastropoda; Trematoda; freshwater; trematodiases; biogeography; Bhutan.

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INTRODUCTION

The present paper is based on a small collection of shells of freshwater snails from Bhutan. It is the first article ever that is devoted to freshwater snails occurring in Bhutan. All the locality data are new and nearly all species have not been reported from that country before. The few species that have been mentioned being simply from 'Bhutan' in the literature, without any further detail, may actually be from present-day Indian territory. The shells were collected within the scope of a more general inventory of the evertebrate animals of Bhutan, directed by the National Biodiversity Centre in Serbithang, Thimphu, Bhutan, in co-operation with partner institutes like the Ugyen Wangchuck Institute for Conservation and Environment, Bumthang, Bhutan, and the Naturalis Biodiversity Center, Leiden, The Netherlands.

Freshwater snails may be useful as a measure for ecological water quality, as it is implemented in nearby Nepal (Shah et al., 2011). Even more important, it is the fact that several species of aquatic snails that were recorded in Bhutan are essential for the life cycle of trematodes and, indirectly, for the infection of both humans and livestock (Lockyer et al., 2004, Mas-Coma, 2005, Chontananarth & Wongawad, 2013, and literature therein). At the 'Third Global Meeting of the Partners for Parasite Control', held in the WHO Headquarters, Geneva, in November 2004, it was concluded that trematodiases have a great impact on human health and development (World Health Organisation, 2005). Human fascioliasis or 'liver rot', as it is called, may result from drinking contaminated water or eating raw vegetables in an area where particular species of snails occur (Soli-

man, 2008, Ramachandran et al., 2012, Anupam Pati Tripathi et al., 2013). Because Ramachandran et al. (2012) have reported human fascioliasis, for example in nearby Arunachal Pradesh and W. Bengal in India, the disease might occur in Bhutan as well. The occurrence of trematodes with freshwater snails in Nepal was mentioned by Devkota et al. (2011) and Budha (2016). To judge the risk of these parasitic diseases, it is relevant to know what species of freshwater snails occur in a particular region. When that kind of data is available, the vast literature on trematodes and snails can be used.

For more detailed descriptions of the habitats of the various species, we refer to a recent monograph on the aquatic invertebrates of the Ganga river system, published by Nesemann et al. (2007). The Middle Brahmaputra ecoregion (Mitra et al., 2010: 57), extending into southern Bhutan, is closely related to the Ganga river system, so that the study by Nesemann et al. (2007) could be used as the basis for this article. Another important paper on freshwater molluscs from Nepal and North India was recently published by Glöer & Bössneck (2013). To summarize the data regarding the freshwater molluscs of the Eastern Himalaya, we refer to Budha et al. (2010). For an overview of the entire freshwater biodiversity of the Eastern Himalaya, see Allen et al. (2010).

MATERIAL AND METHODS

Shells of freshwater snails were collected by several participants of the "Bhutan Invertebrate Biodiversity Survey Project", in or near water, and occasionally among leaves or plants in very humid places. Many areas have not been explored yet and species with shells that are less than 1 cm in height or width, are underrepresented because sieving aquatic bottom samples has only rarely been done, thus relatively small shells may have been overlooked.

A recent monograph on the aquatic invertebrates of the Ganga river system (Nesemann et al., 2007) and articles on freshwater molluscs from Nepal and North India (Glöer & Bössneck, 2013; Budha, 2016) were used to identify the shells collected in Bhutan.

Under the heading "Parasitology", data regarding trematodes are mentioned. This is always based on data in the literature for regions outside Bhutan.

A *Thiara* (*Tarebia*) species that is reported from "Bhutan" in the IUCN Red List (Budha, 2010, 2016), without further details, is included in the identification key, and is only dealt with in short. The common Asian planorbid *Indoplanorbis exustus* (Deshayes, 1834) is also in the identification key, although no records for Bhutan are known to us.

The number of shells is indicated after the locality number. All specimens are in the collection of the National Biodiversity Centre, Serbithang, Thimphu, Bhutan.

References to citations in the literature are restricted to the original descriptions and to illustrations that may be helpful for species recognition.

Study area: localities

1a. Dzongkhag Bumthang, NE of Yotong La, 10 km ENE of Trongsa, 3250 meters a.s.l.; 27°31'N 90°36'E; E. Gittenberger & P. Leda legit 20.IV.2015.

1b. Dzongkhag Bumthang, Wangdicholing School Campus, 2610 meters; 27°33'N 90°44'E; Chimi Yuden legit, 2016

2. Dzongkhag Gasa, Khame, Kabena, 1782 meters a.s.l.; 27°47'N 89°43'E; Rinchen Singye legit, I.2015.

3. Dzongkhag Haa, 15 km WSW of Paro, 2985 meters a.s.l.; 27°23'N 89°16'E; E. Gittenberger & P. Leda legit, 30.III.2016.

4. Dzongkhag Punakha, Toeb, Lamperi lake, 2694 meters a.s.l.; 27°30'N 89°45'E; Sherub Sherub legit, 21.III.2014.

5a. Dzongkhag Samdrup Jongkhar, Samdrupjongkhar, 299 meters a.s.l.; 26°49'N 91°28'E; legit ?, 11.VI.2015.

5b. Dzongkhag Samdrup Jongkhar, Bhayter, 309 meters a.s.l.; 26°53'N 91°44'E; Karma & Tsethup legit, 13.IV.2015.

6. Dzongkhag Sarpang, Chuzagang, Gelephu, Kalikhola, 235 meters a.s.l.; 26°53'N 90°31'E; Sonam Penjor & Sherub Sherub legit, 2013.

7. Dzongkhag Thimphu, 4.5 km E of Chhuzom, W of Genekha, 2750 meters a.s.l.; 27°19'N 89°36'E; E. Gittenberger legit, 21.VI.2012.

8. Dzongkhag Trashigang, Kanglung, campus Sherubtse College, 1850 meters a.s.l.; 27°17'N 91°31'E; donated, III.2016.

9. Dzongkhag Trongsa, Chendebji, 2479 meters a.s.l.; 27°29'N 90°20'E. Dzongkhag Trongsa, Jigme Wangchuk & Sherub Sherubleg, 7.IX.2016.

10. Dzongkhag Wangdue Phodrang, Gangchhu, Phobjikha valley, 2883 meters a.s.l.; 27°26'N 90°11'E; Jigme Wangchuk legit, 21.III.2015

11. Dzongkhag Wangdue Phodrang, Gangchhu, Phobjikha valley, 2915 meters a.s.l.; 27°27'N 90°10'E; Jigme Wangchuk legit, 21.III.2015

12. Dzongkhag Zhemgang, Ngangla Trong; Sangay Dorji & Tsethup Tshering legit [no additional data].

RESULTS

KEY TO THE SPECIES

1a. Shell broader than high: Planorbidae...............2
1b. Shell higher than broad...................................4

2a. Much less than 1 cm broad: *Gyraulus* spec......3
2b. More than 1 cm broad....*Indoplanorbis* spec. (not known from Bhutan)

3a. Less than 3 mm broad, body whorl evenly rounded, protoconch in line with the teleoconch whorls..*Gyraulus rotula*
3b. More than 4 mm broad, body whorl obliquely rounded, only protoconch conspicuously deepened ....*Gyraulus sivalensis*

4a. Less than 3 mm high: *Erhaia* spec....................5
4b. Much larger..6

5a. Umbilicus very narrow; aperture touching the penultimate whorl................................*Erhaia* sp. 1
5b. Umbilicus widely open; aperture not touching the penultimate whorl.................*Erhaia wangchuki*

6a. Shell fragile, brownish to yellowish, without any colour pattern or sculpture; without operculum: Lymnaeidae...7
6b. Shell not fragile, with a prominent sculpture or a colour pattern; with an operculum......................9

7a. Shell height less than 1.5 cm............................8
7b. Shell height over 1.5 cm, aperture large, measuring ca ¾ of the total shell height........................ ....*Lymnaea acuminata*

8a. Height usually much less than 1 cm, spire as high as the aperture or higher.......*Galba truncatula*
8b. Height much more than 8 mm, aperture higher than the spire..........................*Radix andersoniana*

9a. Obliquely ovoid....................*Paludomus conica*
9b. Slender or very slender conical......................10

10a. Yellowish green with darker spiral bands......... ....*Bellamya* (*Filopaludina*) *bengalensis*
10b. Without spiral colour bands..........................11

11a. Shell large, up to nearly 5 cm high, whorls flattened and nearly smooth (shells from Bhutan).... ....*Brotia costula*
11b. Shell smaller, whorls with a spiral and a radial sculpture...12

12a. Whorls flattened; with 5 or 6 rather coarse spiral ridges below the periphery of the last whorl.......14
12b. Whorls moderately convex; with more than 6 spiral ridges below the periphery of the last whorl..13

13a. With fine spiral lines and prominent, oblique, radial elevations which may form spines............... ....*Thiara* (*T.*) *scabra*
13b. Spiral and radial sculpture about equally prominent, without spines..........*Melanoides tuberculata*

14a. Short radially elongated tubercles above the periphery...........*Thiara* (*Tarebia*) *lineata* (not seen)
14b. Some spiral rows of prominent roundish tubercles above the periphery...*Thiara* (*Tarebia*) *granifera*

SYSTEMATICS

Subclassis CAENOGASTROPODA Cox, 1960
Superfamilia VIVIPAROIDEA Gray, 1847
Familia VIVIPARIDAE Gray, 1847
Subfamilia BELLAMYINAE Rohrbach, 1937
Genus *Bellamya* Jousseaume, 1886
Type species: *Bellamya duponti* (De Rochebrune, 1882) (? = *Bellamya unicolor* (Olivier, 1804). See Brown (1994)
Subgenus *Filopaludina* Habe, 1964
Type species: *Vivipara bengalensis* Lamarck, 1822

Bellamya* (*Filopaludina*) *bengalensis (Lamarck, 1822) (Fig. 1)

Paludina bengalensis - Lamarck, 1822: 174.
Bellamya (*Filopaludina*) *bengalensis* - Nesemann et al., 2007: 73, pl. 19 figs 2, 3, pl. 20 fig. 1.
Bellamya bengalensis - Devkota et al., 2015: 862. Budha, 2016: 34, fig.

EXAMINED MATERIAL. Loc. 5a, 5 ex.

DESCRIPTION. Shell conical with convex whorls, yellowish green with more than five brown, spiral, colour bands, that alternate in width. The largest shell from Bhutan measures 26.5×18.0 mm. Much larger specimens have been reported from elsewhere; Nesemann et al. (2007: 83, fig. 1) have figured a shell of 39.5 mm height.

NOTES. Species of the family Viviparidae, which are eaten in certain regions of Asia, like Nepal (Budha et al., 2010: 51, 52), "*serve as important intermediate hosts for human trematode infections*" (Brandt, 1974: 19). Nesemann et al. (2007: 73) and Budha (2016: 35) report this Oriental species from many types of lowland water bodies. The locality in Bhutan is situated at 299 meters a.s.l.

Vivipara bengalensis nepalensis Kobelt, 1909, the holotype of which was figured by Zilch (1955: pl. 5, fig. 39), differs by more slender shells with only four, or occasionally five, spiral bands. That nominal taxon was considered a junior synonym of *Filopaludina filosa* (Reeve, 1863) by Brandt (1974: 24). We refrain from using subspecies in *Filopaludina* Habe, 1964.

PARASITOLOGY. See the note on the family.

Superfamilia CERITHIOIDEA Fleming, 1822
Familia PACHYCHILIDAE P. Fischer et Crosse, 1892
Genus *Brotia* H. Adams, 1866
Type species: *Melania pagodula* Gould, 1847

Brotia costula (Rafinesque, 1833) (Figs. 2, 3)

Melania costula - Rafinesque, 1833: 166.
Brotia costula - Köhler & Glaubrecht, 2001: 284, fig. D, 295, 297, fig. 10A - H. Budha, 2016: 41, fig.
Brotia costula costula - Brandt, 1974: 181, pl. 13 figs. 37, 38. Nesemann et al., 2007: 72, 81, pl. 18 fig. 1.

EXAMINED MATERIAL. Loc. 5a, 5 ex.

DESCRIPTION. Shell very slender conical, with flattened whorls, dark greenish brown. Aperture greyish white, slightly pointed instead of broadly rounded basally. Except for irregular growthlines, the shells from Bhutan have an inconspicuous sculpture. There may be about six, vague spiral ribs on the shell base and equally inconspicuous, oblique, radial ribs above the periphery. Apical whorls are missing in all shells. The largest shell measures 48.2×19.4 mm.

NOTES. This conspicuous Oriental species, occurring at ca. 300 meters a.s.l. in Bhutan, is reported from Nepal by Budha (2016: 41, fig). The shell that is illustrated for this species differs from the Bhutanese specimens by the presence of prominent radial riblets. The shells of *B. costula* are quite variable in sculpture (Brandt, 1974: 181). According to Nesemann et al. (2007: 72), its habitat are "*moderately fast running streams and rivers of lowlands*", whereas Budha (2016: 41) mentions "*Clear creeks with sandy bottoms, large rivers, even ponds*". Köhler & Glaubrecht (2001) report this species (p. 296) from both Sikkim and (p. 298) "*Dooars, West Bhutan*" after a sample in The Natural History Museum (London), overlooking the fact that the British annexed the Dooars in 1865, after the Anglo-Bhutan war, so that the Dooars eventually became a part of India.

On the basis of some shells only, it is not possible to classify the sample at the subspecific level.

PARASITOLOGY. For a subspecies of *B. costula*, Davis (1971) reported that it may act as a host species for the oriental lung fluke *Paragonimus westermani* Kerbert, 1878. Wilke et al. (2000: 457) also refer to this association. Singh et al. (2012) reported the connection between *Brotia* and *Paragonimus* Braun, 1899, and indicated (p. 196, fig. 2) that human paragonimiasis has been diagnosed in Arunachal Pradesh.

Familia PALUDOMIDAE Stoliczka, 1868
Subfamilia PALUDOMINAE Stoliczka, 1868
Genus *Paludomus* Swainson, 1840
Type species: *Melania conica* Gray, 1834

Paludomus conica (Gray, 1833) (Figs. 4, 5)

Melania conica - Gray, in Griffith & Pidgeon, 1833: pl. 14 fig 5 [legend]. See Petit & Coan (2008) for bibliographical data.

Paludomus conica - Nesemann et al., 2007: 72, 81, pl. 18 fig 3.

EXAMINED MATERIAL. Loc. 6, 5 ex.

DESCRIPTION. Shell obliquely ovoid, solid, dark brown with one or two very dark spiral bands; with a very large last whorl, determining nearly the total shell height.The largest of 5 shells measures 23.5×16.1 mm.

NOTES. An Oriental species that has been reported from Nepal and Bhutan by Nesemann et al. (2007: 72), who describe its habitat as "*small lowland rivers and streams with pebbly, gravel or sand substrate*". It remains unclear, however, whether "Bhutan" refers to present-day Bhutan (see the notes with *Brotia costula*). Budha & Daniel (2010) also mentioned the species for "Bhutan" without further details.

Petit & Coan (2008) pointed at the fact that *Melania conica* Say, 1821, is a senior homonym of *Melania conica* Gray, 1833.

PARASITOLOGY. No data.

Familia THIARIDAE Gill, 1871
Genus *Thiara* Röding, 1798
Type species: *Helix amarula* Linnaeus, 1758

Thiara* (*Thiara*) *scabra (Müller, 1774) (Fig. 6)

Buccinum scabrum - Müller, 1774: 136.
Thiara (*Thiara*) *scabra* - Nesemann et al., 2007: 69, 80, pl. 17 fig. 8.
Thiara scabra - Brandt, 1974: 163, pl. 12 fig. 8. Budha, 2016: 39, fig.

EXAMINED MATERIAL. Loc. 5a, 1 ex.; 6, 1 ex.

DESCRIPTION. Shell slender conical, dark yellowish brown, with moderately convex whorls; with prominent, oblique, slightly undulating radial ribs that may form a spiral row of spines above the periphery, and additionally fine spiral ridges that become somewhat coarser towards the lower parts of the whorls, crossed by fine growthlines. Apical whorls missing in both shells. The largest specimen (loc. 5) measures 25.9[+ ?] × 10.6 mm.

NOTES. An Oriental species, occurring up to 450 meters a.s.l. in Nepal according to Nesemann et al. (2007: 70), who summarized the habitat as "*rivers and streams .. and stony to muddy substrate*". The two localities known for Bhutan are below 300 meters a.s.l.

PARASITOLOGY. Chontananarth (2015) reported a low infection rate by *Philophthalmus* sp. in *Thiara scabra*. Commonly known as oriental avian eye fluke, it has mainly been found in eyes of several bird species, but infections of humans are also known.

Subgenus *Tarebia* H. et A. Adams, 1854
Type species: *Melania granifera* Lamarck, 1822

NOTES. Two species of *Thiara* (*Tarebia*) are mentioned for Bhutan (Budha, 2010, 2016; Madhyastha & Dutta, 2012), viz. *Thiara* (*Tarebia*) *lineata* (Gray, 1828) and *Thiara* (*Tarebia*) *granifera* (Lamarck, 1822). These species are recognized by both Nesemann (2007) and Budha (2016), but their descriptions and the accompanying figures are not entirely congruent. In contrast to this, Brandt (1974: 167, pl. 12 figs 14–18) regarded *Helix lineata* Gray, 1828, and *Melania granifera* Lamarck, 1822, as synonyms.

Thiara* (*Tarebia*) *lineata (Gray, 1828)

Helix lineata - Gray, in Wood, 1828: 24, fig. 68.
Thiara (*Tarebia*) *lineata* - Nesemann et al., 2007: 69, 80, fig. 6.
Tarebia lineata - Budha, 2016: 40, fig.

NOTES. The species is mentioned for Bhutan without further details (Budha, 2010, 2016). Its habitat are "*rivers and streams*" (Budha, 2016: 40).

Thiara* (*Tarebia*) *granifera (Lamarck, 1822)

Melania granifera - Lamarck, 1822: 167.
Tarebia granifera - Brandt, 1974: 167, pl. 12 figs 14–18.
Thiara (*Tarebia*) *granifera* - Nesemann et al., 2007: 69, 80, fig 5.

EXAMINED MATERIAL. Loc. 12, 1 ex.

DESCRIPTION. Shell slender conical, brownish, with flat whorls with some spirally arranged rows

of prominent roundish tubercles above the periphery and spiral lines on the body whorl below the periphery. Height 22–42 mm; width 7–14 mm (after Brandt, 1974: 166).

NOTES. This species, occurring in "*rivers*" (Budha, 2016: 40), is mentioned for Bhutan without further details (Madhyastha & Dutta, 2012). Only a seriously damaged shell of an inaccurate locality is available.

Genus *Melanoides* Olivier, 1804
Type species: *Melanoides fasciolata* Olivier, 1804 (= *Nerita tuberculata* Müller, 1774)

Melanoides tuberculata (Müller, 1774) (Fig. 7)

Nerita tuberculata - Müller, 1774: 191.
Melanoides tuberculatus - Nesemann et al., 2007: 70, 81, pl. 18 figs 4–5, 83, pl. 20 fig 5.
Melanoides tuberculata - Brandt, 1974: 164, pl. 12 figs 9–12. Budha, 2016: 39, fig.

EXAMINED MATERIAL. Loc. 5b, 5 ex.; 6, 1 ex.

DESCRIPTION. Shell very slender and conical, brownish, sometimes with blotches and bands, with more than 10 moderately convex to flattened whorls; with spiral ridges that are crossed by radial riblets. Height 22–42 mm; width 7–14 mm (after Brandt, 1974: 166). The largest shell from Bhutan measures 28.3×8.5 mm.

NOTES. This well-known invasive species is very widely distributed, from the tropics to aquaria worldwide. According to Budha (2016: 40) the snails are "*abundant in streams, rivers*" and less common in stagnant water.

PARASITOLOGY. Krailas et al. (2014) investigated whether this species may act as a vector of human trematode infections in Thailand, and concluded (p. 84) more generally "*that this species can doubtlessly be considered as of considerable medical significance*". For additional data we refer to that paper and articles cited therein.

Superfamilia RISSOOIDEA Gray, 1847
Familia AMNICOLIDAE Tryon, 1863
Genus *Erhaia* Davis et Kuo, 1985
Type species: *Erhaia daliensis* Davis et Kuo, in Davis, Kuo, Hoagland, Chen, Yang & Chen, 1985.

NOTES. *Erhaia* belongs to the Holarctic family Amnicolidae (Wilke et al., 2001; Liu et al., 2014). Two *Erhaia* species are reported here from Bhutan on the basis of few data. For *E. wangchuki* there are molecular data that confirm its classification.

PARASITOLOGY. According to Wilke et al. (2000) *Erhaia* species may host *Paragonimus*.

Erhaia sp. 1 (Fig. 8)

Erhaia spec. - Gittenberger, Sherub & Stelbrink, 2017: 23, fig 3.

EXAMINED MATERIAL. Loc. 7, 1 ex.

DESCRIPTION. Shell ovoid, greyish, with a last whorl measuring more than ¾ of the total shell height; aperture attached to the penultimate whorl for less than ⅓ of the parietal-columellar side, somewhat pointed above and broadly rounded below; umbilicus very narrow; measurements ca. 2.0×1.3 mm.

NOTES. A single very small shell that was collected in an isolated cold spring got lost after being photographed. It is rather similar in size and shape to the two "*Erhaia*" species figured by Nesemann (2007: 78, figs 4–5). Additional data are required to determine its classification in a more reliable way.

Erhaia wangchuki Gittenberger, Sherub et Stelbrink, 2017 (Figs. 9, 10)

Erhaia wangchuki - Gittenberger, Sherub & Stelbrink, 2017: 23, figs 1–2.

EXAMINED MATERIAL. Loc. 10, 3 ex.

DESCRIPTION. Shell conical with a flat apex because the initial ¾-1 whorl is planispiral; 3¼ whorls in total. Growthlines moderately strong, with a more prominent periostracal ridge at more or less regular distances. Teleoconch whorls broadly shouldered and separated by a deeply incised suture. Aperture obliquely ovoid, smooth inside; apertural edge not touching the penultimate whorl. Umbilicus widely open. The holotype is the largest shell and measures 2.2×1.9 mm.

Notes. This species occurs in a spring with pure water that is used in the nearby village of Gangchhu.

Parasitology. See previous species.

Infraclassis PULMONATA Cuvier in Blainville, 1814
Ordo BASOMMATOPHORA Keferstein in Bronn, 1864
Superfamilia Lymnaeoidea Rafinesque, 1815
Familia Lymnaeidae Rafinesque, 1815;
subfamilia Lymnaeinae Rafinesque, 1815
Genus *Radix* Montfort, 1810
Type species: *Radix auriculatus* Montfort, 1810 (= *auricularia* Linnaeus, 1758).

Radix acuminata (Lamarck, 1822) (Fig. 11)

Lymnaea acuminata - Lamarck, 1822: 160. Nesemann et al., 2007: 88, 98, figs 2–5.

Radix acuminata - Glöer & Bössneck, 2013: 152, 154 figs 52–54, 58–60.

Examined material. Loc. 6, 3 ex.

Description. Shell fragile, with a very large aperture, measuring 70-80% of the entire shell height. Aperture with a prominent columellar fold. Apical whorls somewhat flattened, forming an acute spire, separated by a very oblique suture. Our largest shell is 18.7 mm high, whereas Nesemann et al. (2007: 98, figs 2–3) figure a shell that measures 27.4 mm.

In *Radix luteola* (Lamarck, 1822) the sides of the body whorl are running parallel more clearly, and the apical whorls are more convex and separated by a less oblique suture.

Notes. This is a common Oriental species, which occurs in "*slowly running rivers, streams, ponds, lakes and wetlands*" (Nesemann et al. (2007: 88).

While incorrectly assuming that *Lymnaea acuminata* Lamarck, 1822, is not available because of *Limneus acuminatus* Brongniart, 1810, Hubendick (1951: 157, 158 fig. 344a–g, 179) used the name *Lymnaea auricularia rufescens* Gray, 1822, for this species. *Radix auricularia* (Linnaeus, 1758) is not listed for the Ganga river system by Nesemann et al. (2007). The shell figured by Budha (2016: 43, fig) for "*Lymnaea acuminata*" differs from the Bhutanese specimens by a less acute spire.

Parasitology. *Radix acuminata* may transmit the trematodes (= flukes) *Fasciola hepatica* Linnaeus, 1758 and *F. gigantica* Cobbold, 1855. Chontananarth & Wongawad (2013: 238), in an article on trematodes in freshwater snails in northern Thailand, probably refer to this species as *Lymnaea auricularia rubiginosa* (Michelin, 1831).

Radix andersoniana (Nevill, 1881) (Fig. 12)

Limnaea andersoniana - Nevill, 1881: 142, pl. 5 fig. 9.
? *Lymnaea* (*Radix*) *viridis* Quoyet et Gaimard, 1832; Brandt, 1974: 231, pl. 16 fig 97.
"*Lymnaea andersoniana simulans*" - Nesemann et al., 2007: 87, 97, pl. 21 figs 6, 7.
Radix andersoniana - Glöer & Bössneck, 2013:153, 154 figs 64, 65.

Examined material. Loc. 1b, 1 ex.

Description. Shell ovoid with a conical spire, with 4¾ narrowly shouldered whorls, corneous brown. Aperture with a conspicuous, broadly reflected, columellar callus, which forms no clear fold. The specimen from Bhutan measures 10.3×6.4 mm.

Notes. Nesemann et al. (2007: 87) report "*Lymnaea*" *andersoniana simulans* (Preston, 1908) from "*small streams of the Nepalese middle-mountains*", while indicating, opposite Brandt (1974: 231), that *Lymnaea viridis* Quoy et Gaimard, 1832, is a separate, closely related species.

Parasitology. According to Brandt (1974: 232), this species is host to the same trematodes as *Radix auricularia.* That implies that it may be "*an important intermediate host of several trematode species in Thailand and other parts of SE Asia*", including both *Fasciola* species. See also the notes for *Radix acuminata*.

Genus *Galba* Schrank, 1803
Type species: *Galba pusilla* Schrank, 1803 (= *Buccinum truncatulum* Müller, 1774).
Galba truncatula (Müller, 1774) (Fig. 13)

Buccinum truncatulum - Müller, 1774: 130.
Galba truncatula - Nesemann et al., 2007: 86, 97, pl. 21 fig 2.

EXAMINED MATERIAL. Loc. 2, 2 ex.; 3, 2 ex.; 7, 4 ex.; 8, 2 ex.; 9, 1 ex.

DESCRIPTION. Shell elongated, slender, conical and nearly twice as high as broad, light brownish, yellowish or greenish, more or less transparent, with very convex whorls that are separated by a deep suture. The largest shell from Bhutan is 7.0 mm high, but from elsewhere in the very large range of the species specimens up to 9 mm high or even larger are known; shell width (much) less than 5 mm.

NOTES. *Galba truncatula* is a Holarctic, amphibious species that may survive periods of dryness. It is known from stagnant waters that may temporarily dry up, shallow borders of lakes, pools, muddy or mossy places, among humid leaves, etc. (E.G., personal observations). There are five records in Bhutan from 1782–2985 meters altitude.

PARASITOLOGY. This species, widespread in the Holarctic region, including parts of Bhutan, is the best known host snail for the trematode *Fasciola hepatica*. Several additional trematodes and nematodes that may be associated are mentioned in the literature. The transmission potential of fascioliasis to humans and to animals is high. For an introduction to the literature on subjects related to this snail species and *Fasciola* Linnaeus, 1758 in humans and animals, we refer to Bargues et al. (2013) and the Internet.

Superfamilia PLANORBOIDEA Rafinesque, 1815
Familia PLANORBIDAE Rafinesque, 1815
Genus *Gyraulus* Charpentier, 1837
Type species: *Planorbis albus* Müller, 1776.

NOTES. Our material of *Gyraulus* specimens is much too limited for a satisfying analysis, but Glöer & Bössneck (2013) made it possible to identify at least two species with reasonable certainty.

PARASITOLOGY. No data for the *Gyraulus* species that were found in Bhutan are known. Brandt (1974: 239–240) mentions *Gyraulus convexiusculus* (Hutton, 1849) as "*first intermediate host of Echinostoma ilocanum and other species of Echinostoma*", known from birds and mammals, while also recording the presence of cercariae of *Paramphistoma* sp. *Echinostoma ilocanum* (Garrison, 1908) is also known from the gastrointestinal tract in humans. For additional data on the occurrence in Asia, see also Toledo et al. (1995) and Woon-Mok et al. (2011).

Gyraulus rotula (Benson, 1850) (Fig. 14)

Planorbis rotula - Benson, 1850: 351. Glöer et Bössneck, 2013: 148, figs 33, 34.

EXAMINED MATERIAL. Loc. 6, 10 ex.

DESCRIPTION. Shell discoid, very small, periphery rounded; final whorl rapidly increasing in width, when viewed from both above and below. Width 2.9-3.5 mm (shells from Bhutan).

Gyraulus sivalensis (Clessin, 1884) (Figs. 15, 16)

Planorbis sivalensis - Clessin, in Küster et al., 1884: 194, pl. 28 fig 9.

EXAMINED MATERIAL. Loc. 1a, 2 ex.; 4, 12 ex.

DESCRIPTION. Shell discoid, larger than the previous species, periphery rounded; only the protoconch deeply immersed at both sides; final whorl little increasing in width at the apical side (shell considered sinistral). The largest shell from Bhutan is 5.0 mm broad.

DISCUSSION

Nesemann et al. (2007) deal with 34 species of Caenogastropoda and 20 species of Pulmonata for the Ganga river system, whereas Budha et al. (2010: 45, Table 4.3) mention 78 species of Caenogastropoda and 33 species of Pulmonata for the Eastern Himalaya. We can report with certainty only 9 species of Caenogastropoda and 5 species of Pulmonata for Bhutan. Not all the species listed by Nesemann et al. (2007) will occur in Bhutan, but we may assume that there will be more than those that are reported here. Also, because of the small number of localities where shells have been collected, without sieving the substrate, we predict that the real number of gastropod species occurring in Bhutan will prove to be considerably higher.

Several gastropod species are known as hosts for trematodes that are important for lifestock and

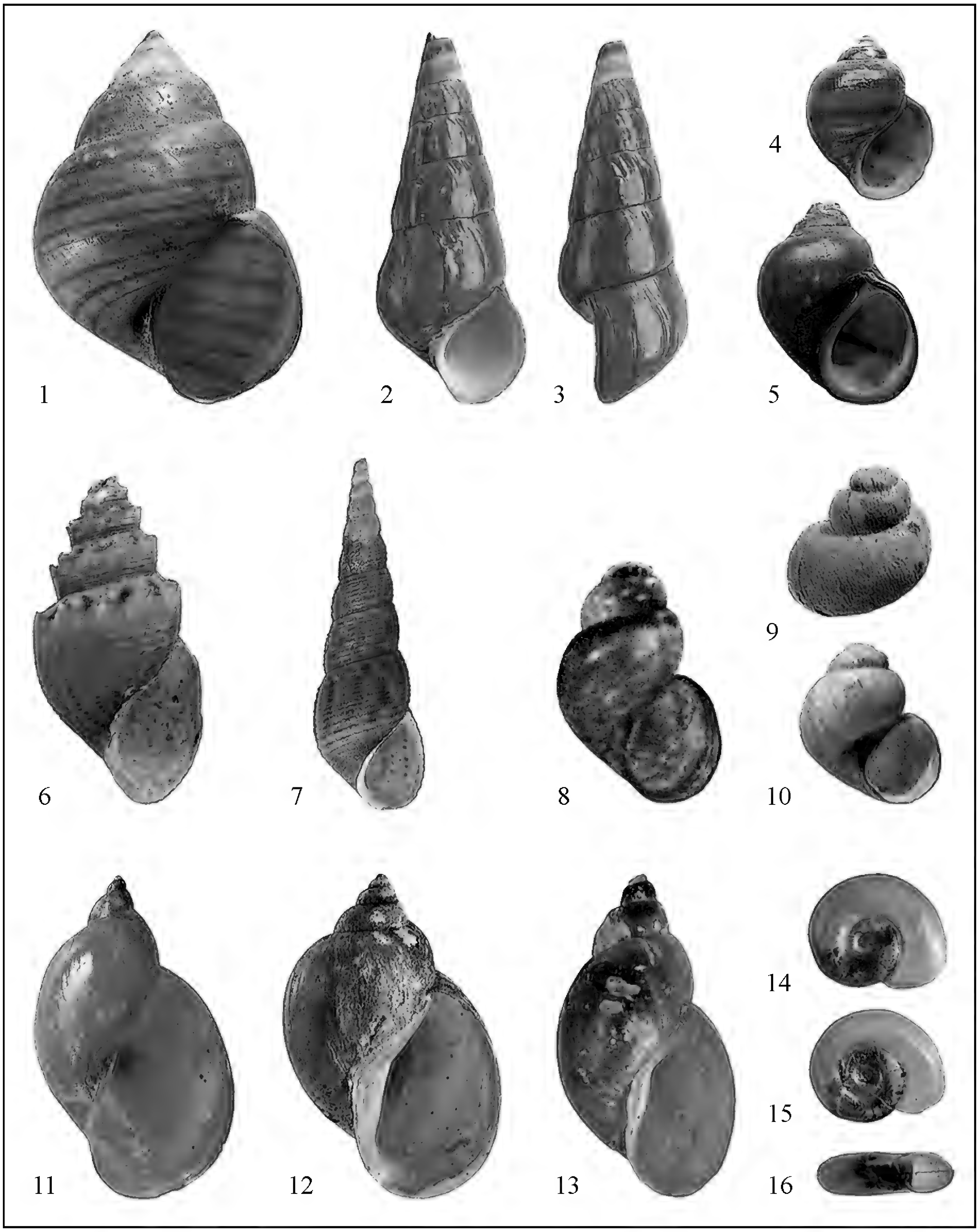

Figure 1. *Bellamya* (*Filopaludina*) *bengalensis*. Loc. 5a, height 25.6 mm. Figures 2, 3. *Brotia costula*. Loc. 5a, height 47.2 mm. Figures 4, 5. *Paludomus conica*. Loc. 6, heights 23.5 and 19.5 mm. Figure 6. *Thiara scabra*. Loc. 6, height 17.0 mm. Figure 7. *Melanoides tuberculata*. Loc. 5b, height 28.3 mm. Figure 8. *Erhaia* sp. 1. Loc. 7, height c. 2.0 mm. Figures 9, 10. *Erhaia wangchuki*. Loc. 10, height 2.2 mm. Figure 11. *Radix acuminata*. Loc. 6, height 18.7 mm. Figure 12. *Radix andersoniana*. Loc. 1b, height 10.0 mm. Figure 13. *Galba truncatula*. Loc. 2, height 7.0 mm. Figure 14. *Gyraulus rotula*. Loc. 6, maximal diameter 3.0 mm. Figures 15, 16. *Gyraulus sivalensis*. Loc. 4, maximal diameter 4.0 mm.

human well-being. At present, this fact is not sufficiently well known in Bhutan. Eating raw vegetables washed in unboiled water, where snails occur nearby, or drinking water directly from a brooklet or pond, is not advisable. A detailed survey of the aquatic gastropods of Bhutan, their distribution and the percentages of contamination with trematodes, is necessary to underpin this statement.

CONCLUSIONS

The freshwater gastropod fauna of Bhutan belongs to the Ganga & Brahmaputra river system with endemism observed only in *Erhaia*. That genus is represented in isolated spring areas, triggering allopatric speciation. Several species of snails that occur in the country are well-known hosts for trematodes. Therefore, both humans using unboiled water and livestock are at risk of trematodiases.

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REFERENCES

Allen D.J., Molur S. & Daniel B.A. (Eds.), 2010. The status and distribution of freshwater biodiversity in the Eastern Himalaya. IUCN, Cambridge, U.K. and Gland, Switzerland, viii + 88 pp.

Anupam, Pati Tripathi, SinghV.K. & Singh D.K., 2013. Behavioral responses of the snail *Lymnaea acuminata* towards photo and chemo attractants: A new step in control program of fasciolosis. International Journal of Zoology, 2013: 1–6. pp.http://dx.doi.org/10.1155/2013/439276

Bargues M.D., Artigas P., Khoubbane M., Ortiz P., Naquira C. & Mas-Coma S., 2012. Molecular characterisation of *Galba truncatula*, *Lymnaea neotropica* and *L. schirazensis* from Cajamarca, Peru and their potential role in transmission of human and animal fascioliasis. Parasites & Vectors, 5: 174–189. http://www.parasitesandvectors.com/content/5/1/174

Benson W.H., 1850. Characters of nine new or imperfectly described species of *Planorbis* inhabiting India and China. The Annals and Magazine of Natural History, (2) 5 (29): 348–352. http://www.biodiversitylibrary.org/item/53365

Brandt R.A.M., 1974. The non-marine aquatic Mollusca of Thailand. Archiv für Molluskenkunde, 105: 1–423.

Brown D.S., 1994. Freshwater snails of Africa and their medical importance. CRC Press, Taylor & Francis, Abingdon, U.K., 608 pp.

Budha P.B., 2010. *Tarebia lineata*. The IUCN Red list of threatened species 2010: e.T166747A6274430. http://dx.doi.org/10.2305/IUCN.UK.2010-4.RLTS.T166747A6274430.en

Budha P.B., 2016. A field guide to freshwater molluscs of Kailali, far western Nepal. Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu, Nepal, 7 + 85 pp.

Budha P.B., Aravind N.A. & Daniel B.A., 2010. The status and distribution of freshwater molluscs of the Eastern Himalaya. Chapter 4. In: Allen D.J., Molur S., Daniel B.A. (Eds.), The status and distribution of freshwater biodiversity in the Eastern Himalaya. IUCN, Cambridge, U.K. and Gland, Switzerland: 42–53. www.researchgate.net/profile/David_Allen9/publication/236681659_The_Status_and_distribution_of_Freshwater_Biodiversity_in_the_Eastern_Himalaya.pdf

Budha P.B. & Daniel B.A., 2010. *Paludomus conica*. The IUCN red list of threatened species 2010: e. T166707A6265957.http://dx.doi.org/10.2305/ IUCN. UK.2010- 4.RLTS.T166707A6265957.en

Chontananarth T., 2015. Epidemiological situation of the trematode *Philophtalmus* (Trematoda: Philophtalmidae) in northern Thailand. Proceedings of the 8th AMC and the 32nd MST Annual Conference. 28–30 January 2015, Nakhon Pathom, Thailand: 245–248.

Chontananarth T. & Wongawad C., 2013. Epidemiology of cercarial stage of trematodes in freshwater snails from Chiang Mai province, Thailand. Asian Pacific Journal of Tropical Biomedicine, 3: 237–243.

Clessin S., 1884. In: Küster H.C., Dunker W. & Clessin S., 1841–1886. Die Familie der Limnaeiden enthaltend die Genera *Planorbis*, *Limnaeus*, *Physa* und *Amphipeplea*. Martini & Chemnitz, Systematisches Conchylien-Cabinet (Ed. 2) I.17: 111–222. Nürnberg. www.biodiversitylibrary.org/item/102123

Davis G.M., 1971. Systematic studies of *Brotia costula* episcopalis, first intermediate host of *Paragonimus westermani* in Malaysia. Proceedings of the Academy of Natural Sciences of Philadelphia, 123: 53–86. http://www.jstor.org/stable/4064670

Davis G.M., Kuo Y.-H., Hoagland K.E., Chen P.-L., Yang H.-M. & Chen D.-J., 1985. *Erhaia*, a new genus and new species of Pomatiopsidae from China (Gastropoda: Rissoacea). Proceedings of the Academy of Natural Sciences of Philadelphia, 137: 48–78. http://www.jstor.org/stable/4064860

Devkota R., Budha P.B. & Gupta R., 2011. Trematode cercariae infections in freshwater snails of Chitwan district, Central Nepal. Himalayan Journal of Sciences, 7: 9–14. https://www.researchgate.net/publication/274253362

Devkota R., Brant S.V. & Loker E.S., 2015. The *Schistosoma indicum* species group in Nepal: presence of a new lineage of schistosome and use of the *Indoplanorbis exustus* species complex of snail hosts. International Journal for Parasitology, 45: 857–870.

Gittenberger E., Sherub S. & Stelbrink B., 2017. *Erhaia* Davis & Kuo (Gastropoda, Rissooidea, Amnicolidae) also in Bhutan. ZooKeys, 679: 21–28. Doi: 10.3897 /zookeys.679.13326

Glöer P. & Bössneck U., 2013. Freshwater molluscs from Nepal and North India with the description of seven new species (Gastropoda: Bithyniidae, Lymnaeidae, Planorbidae). Archiv für Molluskenkunde, 142: 137–156.

Griffith E. & Pidgeon E.,1833–1834. The Mollusca and Radiata12. In: Griffith E. (Ed.) [1824]–1835, The animal kingdom arranged in conformity with its organization, by the Baron Cuvier, member of the Institute of France, & c. with supplementary additions to each order, by Edward Griffith, F.L.S., A.S., corresponding member of the Academy of Natural Sciences of Philadelphia, & c. and others. London, Whittaker and Co., viii + 601 pp., 61 pls.

Hubendick B., 1951. Recent Lymnaeidae. Their variation, morphology, taxonomy, nomenclature, and distribution. Kunglica Svenska Vetenskaps akademiens Handlingar (Fjärde Serien), (4) 3 (1): 1–223, pls. 1–5.

Hutton T., 1849. Notices of some land- and fresh-water shells occurring in Afghanistan. Journal of the Asiatic Society of Bengal, 18: 649–661. www.biodiversitylibrary.org/item/124014

Köhler F. & Glaubrecht M., 2001. Towards a systematic revision of the southeast Asian freshwater gastropod *Brotia* H. Adams, 1866 (Cerithioidea: Pachychilidae): an account of species from around the South China Sea. Journal of Molluscan Studies, 67: 281–318. https://doi.org/10.1093/mollus/67.3.281

Krailas D., Namchote S., Koonchornboon T., Dechruksa W. & Boonmekam D., 2014. Trematodes obtained from the thiarid freshwater snail *Melanoides tuberculata* (Müller, 1774) as vector of human infections in Thailand. Zoosystematics and Evolution, 90: 57–86. https://doi.org/10.3897/zse.90.7306

Lamarck J.B.P.A. de Monet de, 1822. Histoire naturelle des animaux sans vertèbres .., 6 (2). Published by the author, Paris,iii + 232 pp. Paris. http://biodiversitylibrary.org/item/47433

Liu L., Huo G.-N., He H.-B., Zhou B.& Attwood S.W., 2014. A phylogeny for the Pomatiopsidae (Gastropoda: Rissooidea): a resource for taxonomic, parasitological and biodiversity studies. BMC Evolutionary Biology, 14: 1–30. http://www.biomedcentral.com/1471-2148/14/29

Lockyer A.E., Jones C.S., Noble L.R. & Rollinson D., 2004. Trematodes and snails: an intimate association. Canadian Journal of Zoology, 82: 251–269. https://doi.org/10.1139/z03-215

Madhyastha A. & Dutta J., 2012. *Tarebia granifera*. The IUCN Red List of Threatened Species 2012: e.T165813A1102513. http://dx.doi.org/10.2305/IUCN.UK.2012-1.RLTS.T165813A1102513.en.

Mas-Coma S., 2005. Epidemiology of fascioliasis in human endemic areas. Journal of Helminthology, 79: 207–216.

Mitra A., Dow R., Subramanian K.A. & Sharma G., 2010. The status and distribution of dragonflies and damselflies (Odonata) of the Eastern Himalaya. Chapter 5. In: Allen D.J., Molur S. & Daniel B.A. (Eds.), The status and distribution of freshwater biodiversity in the Eastern Himalaya. IUCN, Cambridge, U.K. and Gland, Switzerland: 54–67.

Müller O.F., 1774. Vermium terrestrium et fluviatilium, seu animalium Infusoriorum, Helminthicorum, et Testaceorum, non marinorum succinct historia 2: i-xv, 1-214. Heinec and Faber, Mülleriana, Havniae et Lipsiae, xxii + 214 pp. http://www.biodiversitylibrary. org/item/50344

Nesemann H., Sharma S., Sharma G., Khanal S.N., Pradhan B., Shah D.N. & Tachamo R.D., 2007. Class Gastropoda, in: Aquatic invertebrates of the Ganga river system (Mollusca, Annelida, Crustacea [in part]): 57–102.

Nevill G., 1881. New or little known Mollusca of the Indo-Malayan fauna. Journal of the Asiatic Society of Bengal, 50: 125–167. https://biodiversitylibrary.org/page/35598060.

Petit R.E. & Coan E.V., 2008. The molluscan taxa made available in the Griffith & Pidgeon (1833–1834) edi-

tion of Cuvier, with notes on the editions of Cuvier and on Wood's Index Testaceologicus. Malacologia, 50: 219–264. https://doi.org/10.4002/0076-2997-50.1.219

Rafinesque C.S., 1833. On 5 new fresh water shells, of Bengal and Assam in Asia. Atlantic Journal and Friends of Knowledges, 5: 165–170.

Ramachandran J., Ajjampur S.S.R., Chandramohan A. &Varghese G.M., 2012. Case of human fascioliasis in India: tip of the iceberg. Journal of Postgraduate Medicine, 58: 150–152.

Shah R.D.T., Shah D.N. & Nesemann H.F., 2011. Development of a macroinvertebrate-based Nepal Lake Biotic Index (NLBI): an applied method for assessing the ecological quality of lakes and reservoirs in Nepal. International Journal of Hydrology Science and Technology, 1: 125-146. Doi: 10.1504/IJHST.2011.040744

Singh T.S., Sugiyama H. & Rangsiruji A., 2012. *Paragonimus* & paragonimiasis in India. Indian Journal of Medical Research, 136: 192–204. PMCID: PMC34 61730

Soliman M.F.M., 2008. Epidemiological review of human and animal fascioliasis in Egypt. The Journal of Infection in Developing Countries, 2: 182–189. Jidc.org/index.php/journal/article/view/19738348/148

Toledo R., Esteban J.G. & Fried B., 2012. Current status of food-borne trematode infections. European Journal of Clinical Microbiology and Infectious Diseases, 31: 1705–1718.

Wilke T., Davis G.M., Falniowski A., Giusti F., Bodon M. & Szarowska M., 2001. Molecular systematics of Hydrobiidae (Mollusca: Gastropoda: Rissooidea): testing monophyly and phylogenetic relationships. Proceedings of the Academy of Natural Sciences of Philadelphia, 151: 1–21. http://www.jstor.org/stable/4065080

Wilke T., Davis G.M., Gong X. & Liu H.-X., 2000. *Erhaia* (Gastropoda: Rissooidea): phylogenetic relationships and the question of *Paragonimus* co-evolution in Asia. The American Journal of Tropical and Hygiene, 62: 453–459.

Wood W., 1828. Index testaceologicus; or a catalogue of shells, British and foreign. Published by the author, London, iv + 59 pp., 8 pls. www.biodiversitylibrary.org/item/55010

Woon-Mok S., Hyeong-Jin K. Tai-Soon Y., Keeseon S.E., Hoo-Gn J., Jae-Kwang K., A-Reum K., Mok-Ryun K., Jung-Mi P., Soo-Hyeon J., Muth S., Duong S. & Jong-Yil C., 2011. *Echinostoma ilocanum* infection in Oddar Meanchey Province, Cambodia. The Korean Journal of Parasitology, 49: 187–190. Doi: 10.3347/kjp.2011. 49.2.187

World Health Organization, 2005. Deworming for health and development: report of the third global meeting of the partners for parasite control. World Health Organization, Geneva, v + 51 pp. http://www.who.int/wormcontrol

Zilch A., 1955. Die Typen und Typoide des Natur-Museums Senckenberg, 14: Mollusca, Viviparidae. Archiv für Molluskenkunde, 84: 45–86.

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A new Vermetidae from the Eastern Atlantic: *Vermetus bieleri* n. sp. (Gastropoda Caenogastropoda)

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ABSTRACT A new species of the worm-snail *Vermetus* Daudin, 1800, *V. bieleri* n. sp. (Gastropoda Caenogastropoda), is here described as new for Madeira and the Canary Islands. The species morphologically resembles the Mediterranean congener *V. triquetrus* Bivona, 1832, from which it is here distinguished on the basis of morphological characters of the shell, the protoconch and the external soft parts. Comparisons of the new vermetid with other similar species are hereafter reported.

KEY WORDS *Vermetus*; new species; Canary Islands; Madeira; littoral; endemism; phenetic plasticity.

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INTRODUCTION

Vermetidae is a family of sessile gastropods, whose systematic and ecologic knowledge is far to be fully understood. Useful characters for the identification of species of Vermetidae are the shell sculpture, the protoconch features, the form of the first tele-whorl, the colour pattern of external soft parts, the shape of operculum. The so called phenetic plasticity (Via et al., 1995) allows the vermetids high possibilities to produce different morphs according to environmental conditions (Scuderi, 2003), which impose to taxonomists to study a great number of specimens to have a precise idea of the range of variability of a species. The exam of the radula is a useful character for genus classifications.

The european malacofauna comprises a ten of still taxonomically debated species of this family, mainly distributed into the Mediterranean, because of their warm-water preference.

Despite being a common and well known species, no complete and detailed description of *Vermetus triquetrus* Bivona, 1832 is reported in modern times. Some partial descriptions are scattered in several publications (Lacaze-Duthiers, 1860; Morton, 1965; Bandel, 1984: radula; Schiaparelli, 1996; Calvo & Templado, 2004).

In the Eastern Atlantic, apart the four species reported from Madeira by Segers et al. (2009), the Azorean vermetids were studied in detail only by Bieler (1995), who examined and figured the shell characters, the protoconch and the anatomical characters of what he called "*Vermetus* cfr. *triquetrus*", which he associated to a simply morphological variation of the Mediterranean form. New finding of materials from other Eastern Atlantic archipelagos allowed us to conduct more accurate studies on this species, which is here regarded as new to science and distinguished by the morphologically similar Atlantic and Mediterranean con-

geners. Here follows the description of the new vermetid, which enlarges the number of the European species of Vermetidae to 11 extant species.

MATERIAL AND METHODS

Dry materials of the new species of *Vermetus* Daudin, 1800 were collected by undermining the shells from hard substrates at a depth of 0 to 5 m; empty shells were found beached along lava sand beaches or were collected among the shell grit collected handily with ARA. Some specimens were collected alive and preserved in 90° ethanol. From this latter material informations on the external soft parts were obtained for drawings and future genetic studies could be conducted.

Juveniles were found inside egg capsules of some living collected specimens. Protoconchs were obtained by extracting them from the brooding females, as in the holotype, and by digging them with a needle from the base of empty specimens.

The selection of type materials deposited in the under reported Institutions was fundamentally based on living specimens at our disposal, even if they had almost corroded and not fully grown shells. The reasons of this choice depended on the necessity by us to have the absolutely certainty of the correspondence of juveniles and external soft parts, reported in the pictures of the plate, to the shells. This material was incremented with additional not living collected shells. The holotypus was slightly handily cleaned with a needle from the encrusting algae to make visible characters of the shell, but it was not immersed in any cleaning solutions to preserve juveniles attached on it. It bears all the characters described and the presence of the living animal containing juveniles (stored in a separated vial) and other specimens in different growing stages on it facilitate their observation and evaluation.

The private collections of Authors and of Museums allowed comparisons of the new species with the most similar congeners.

ABBREVIATIONS AND ACRONYMS. Museo Municipal do Funchal, Madeira (MMF); Museo Nacional de Ciencias Naturales, Madrid, Spain (MNMS); Royal Belgian Institute of Natural Sciences, Brussels, Belgium (RBINS); Roland De Prins collection, Mechelen, Belgium (RDPC); Danilo Scuderi collection, Catania, Italy (DSC); Frank Swinnen collection, Lommel, Belgium (FSC); d: diameter; h: high; pro: protoconch; sh: empty shell; spec: live taken specimen; w: wide; Ø: external diameter of the tube.

RESULTS

Systematics

Subclassis CAENOGASTROPODA Cox, 1960
Ordo LITTORINIMORPHA Golikov et Starobogatov, 1975
Superfamilia VERMETOIDEA Rafinesque, 1815
Familia VERMETIDAE Rafinesque, 1815
Genus *Vermetus* Daudin, 1800
Type species: *Vermetus adansonii* Daudin, 1800

Vermetus bieleri n.sp. (Figs. 1–21)

Vermetus triquetrus Bivona, 1832 (Watson, 1897);
Bivonia triquetrus Bivona, 1832 (Talavera, 1978; Nordsieck & Talavera, 1979);
Vermetus cfr. *triquetrus* Bivona-Bernardi, 1832 (Bieler, 1995).

EXAMINED MATERIAL. Holotype (Fig. 1): Funchal, Madeira, -10 m, on a lava rock, 30/VII/2017; length 12.1 mm, Ø 2.4 mm (MNMS: 46277), P. Wirtz legit. Paratypes. Paratype 1 (Fig. 2): same data of holotype, length 21.4 mm, Ø 3.8 mm (MMF). Paratype 2: same data of holotype, length 20.2 mm, Ø 5.4 mm (RBINS: I.G.33286/MT.3427). Paratype 3: same data of holotype, length 19.9 mm, Ø 3.8 mm (RDPC). Paratype 4: same data of holotype, length 20.1 mm, Ø 5.0 mm (MNMS). Paratype 5: Caniçal, Madeira, -10 m, on lava rocks, 16/IV/2017, length 21.5 mm, Ø 4.9 mm (MMF). Paratype 6 (Fig. 3): Las Palmas, Gran Canaria, Playa del Hombre, beached. I/1998: length 22.0 mm, Ø 3.8 mm (DSC). Paratype 7 (Fig. 4): same data of paratype 6, length 33.5 mm, Ø 7.1 mm (FSC). Paratype 8 (Fig. 5): same data of paratype 6, length 25.1 mm, Ø 7.0 mm (RBINS). Paratype 9 (Fig. 6): same data of paratype 6, length 38.0 mm (cluster of a ten of sh.), Ø (of the bigger sh.) 6.0 mm (RDPC). Paratype 10

(Fig. 7): same data of paratype 6, length 14.0 mm, Ø 3.1 mm (RBINS).

All the other unnumbered paratypes are in the collection of the Authors and the above reported Institutions.

OTHER EXAMINED MATERIAL. Madeira: Reis Magos, intertidal, on volcanic rocks, 10 spec (Peter Wirtz legit); Porto Santo: south coast, -14/100 m, 10 sh.; Calheta, 2 sh and 5 juv sh, 1 spec. Selvage Is.: Selvagem Pequena, 20 sh, tidal pools; Selvagem Grande, -10 m, 1 sh.

Canary Islands. Las Palmas, Gran Canaria, Playa del Hombre, beached. I/1998, 48 sh. (DSC). La Graciosa: volcanic sand, beached, 4 sh, 4 pro, (DSC); Tenerife: 1 sh on *Stramonita haemastoma* (DSC); Lanzarote: 58 sh, 1 little cluster (2/3 sh), 18 pro (DSC).

DESCRIPTION OF HOLOTYPE (MNMS). Length 21.4 mm, Ø 3.8 mm. Shell solid, irregularly coiling, tube-like, with one main dorsal keel, which give the shell a triangular cross section, and more smaller carinae mainly in the outer part of the tube in each whorl (Fig. 8). Apart the spiral keels, dense growing lines are present over all the tube surface. They are not homogenous: some lines are slightly more relieved alternated to other more faint. The last whorls appear mainly sculptured by a distinct dorsal chord, which become more marked on the last whorls. The colour of the entire shell is almost brownish, stripped by darker lines.

Protoconch inflated, rather as wide as high, constituted by little less than 2 mainly smooth whorls, 0.75/0.8 mm high and 0.6/0.7 mm wide (Figs. 9, 10, 16, 19). The surface appear almost smooth, apart the growing lines. A spiral chord is present at the base of the last whorl. Sometimes the basal chord of the protoconch is well marked, while in other specimens it could appear only as a faint trace, constituted by two poorly visible spiral threads. The first teleoconch whorl is ribbed by not marked axial chords, almost entirely chestnut in colour, rounded in shape (Fig. 9). In the following whorls, in addition to the spirals, the axial lines starts to run over the entire shell surface, particularly in the external side of the whorl, giving sculpture a cancellated weave.

External soft parts of the living animal (Fig. 21) dark greyish-brown or blackish in colour with numerous minutes orange and whitish spots over the metapodium, head and part of cephalic tentacles, almost paler brownish in the remaining parts. Mesopodium whitish like the central region of the mesopodium, just over the operculum, where a series of 3–4 minute black spots is present in a single line, which encircles operculum on the upper side. Mantle edge with alternated black and white stains. Nuchal region with the same colour of the metapodium, which blend to almost pale orange, without giving rise to any particular pattern. A white band is present over the cephalic tentacles. Pedal tentacles almost transparent with yellowish-orange spots.

Operculum (Fig. 12) thin, on the upper centre of the semi-circular podalic disc, 1/3 of the total aperture of the tube, with an internal spiral keel of approximately 1 and ½ coil on the upper slightly concave side, almost smooth and glossy on the lower side.

Egg capsule containing eggs (Fig. 17) and embryos (Fig. 18) were found in two living specimens of the lot in which the holotype was selected. They are 4–5 mm in length and white-yellowish in colour. They perfectly match with the protoconchs of all the other shells studied.

Radula (Figs. 13–15) with laterals (Figs. 13, 14) hook shaped, bicuspidate, with the proximal cusp shorter than the distal, and rachidian (Fig. 15) with one coarse central cusp and two smaller for each side.

VARIABILITY. The maximum dimensions measured of a full extended specimen is 37 mm in length and 22 mm wide, with an external diameter of the tube of 7 mm. Apart the irregular mode of coiling, intraspecific variability regards the shell colour, which ranges from almost entirely purplish-brown to creamy, with some darker lines. Judging from our observations and from literature data, the colour pattern of the living animal seem subjected to a range of variety. As in other species of Vermetidae, the shell sculpture in adult specimens could be more or less marked, depending on environmental conditions (Scuderi, 2003). In full grown specimens, which often are eroded by wave action, the spiral sculpture is often faint or absent, in particular if the specimen produce a feeding tube.

ETYMOLOGY. The name is after the malacologist and vermetids expert Rudiger Bieler, who reported

the species at the Azores for the first time as *V.* cfr. *triquetrus*.

DISTRIBUTION AND BIOLOGY. The species is currently known only from the Azores, Madeira Archipelago and Canary Islands. On the basis of the material described by Monterosato (1892) specimens found along the Atlantic side of Spain is attributable to *V. triquetrus*. The species is able to form little clusters of specimens (Figs. 6–20).

COMPARATIVE NOTES. The new species is similar to some morphologically close similar species, to which it is here compared:

Vermetus triquetrus Bivona, 1832. The Mediterranean *V. triquetrus* has great shell resemblance with the new one for the triangular shape of the section of the tube, due to the presence of a main and marked crest on the top. But in the new species some other less marked spiral chords are present too, mainly on the external side of the shell, better visible in not fully grown specimens. The living animal colour of *V. triquetrus* (Fig. 22) is quite variable, ranging from entirely yellow to completely dark grey, with white dots and strips. But some populations show external soft parts with a similar colour pattern of the new species. The most useful and invariable character to discriminate these two species is the protoconch, which is completely smooth in *V. triquetrus* (Schiaparelli, 1996; Calvo & Templado, 2004).

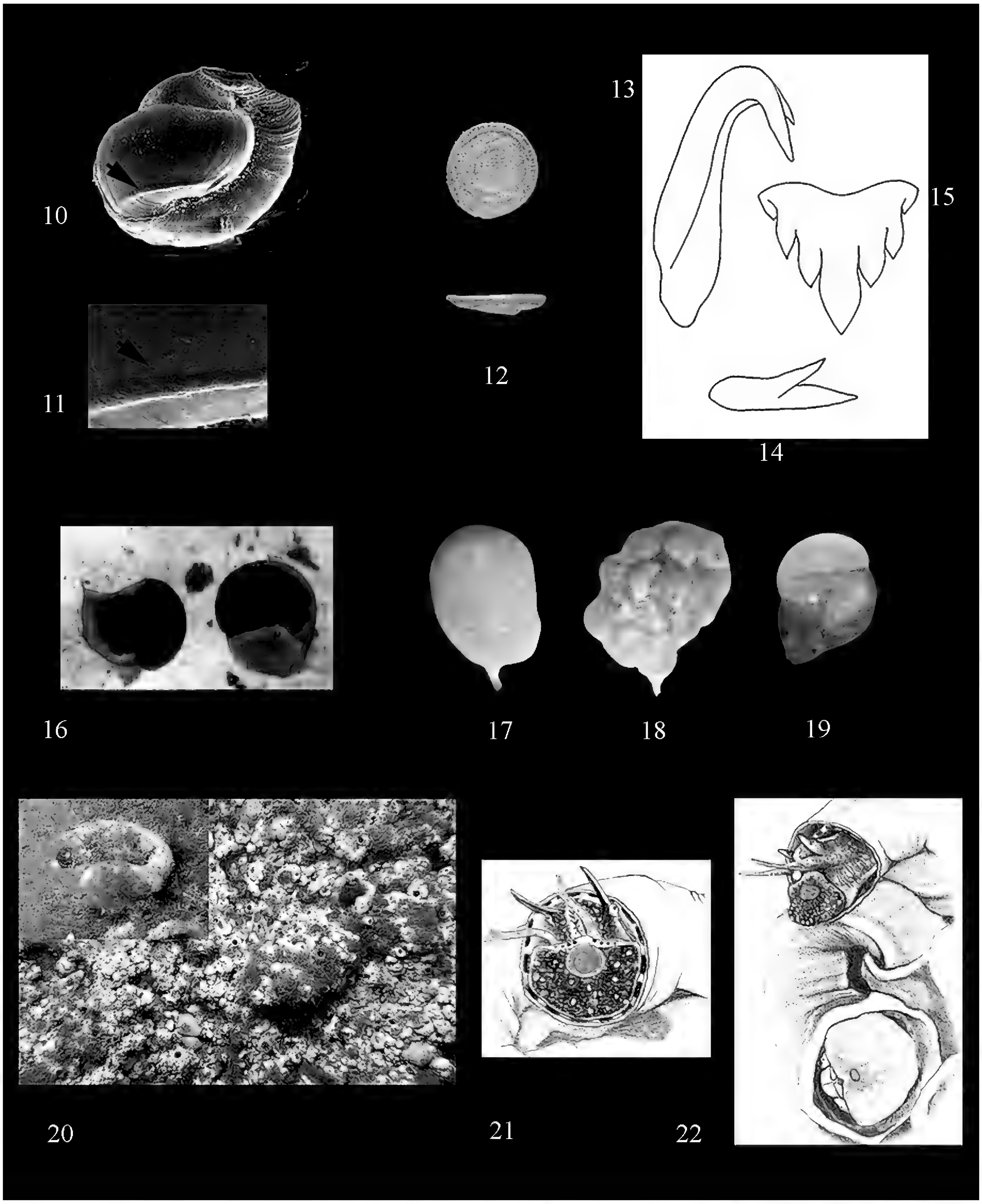
Vermetus adansoni Daudin, 1800. This is an Atlantic species mainly distributed along the W-African rocky shores and the type species of *Vermetus*. The shell morphology of this species is similar to a morpho of the Mediterranean *V. granulatus* called "form A" (Scuderi, 1999), being the spiral sculpture very marked and predominant over the axial ribs. Only young specimens of *V. bieleri* n. sp. could be confused with *V. adansoni* due to the cancellated shell sculpture, but *V. bieleri* n. sp. has a less marked sculpture and protoconch of different shape and with the characteristic basal spiral chords.

Vermetus granulatus (Gravenhorst, 1831). This Mediterranean species shares with *V. bieleri* n. sp. the presence of less marked spiral chords mainly on the external side of the tube, but specimens with almost equally marked spirals are not infrequent. These lines cross the axial sculpture giving it a cancellated aspect. Not fully grown specimens of *V. bieleri* n. sp. are thus similar in shell sculpture and in the almost brownish colour (Figs. 7, 8) to *V. granulatus*. The operculum is similar too, being smaller than the metapodium. Anyway *V. granulatus* has smaller dimensions, reaching 2–3 mm in diameter of the tube and 10–20 mm in length in adult specimens and the protoconch is quite different in general shape and completely smooth; the external soft parts have a different colour pattern (Scuderi, 1999).

Vermetus gaederopi (Mörch, 1861). This species is only recently re-discovered after hits original description and its distribution is known with certainty only after the new recent finding, some Sicilian localities, being the type material doubtfully reported as coming "*probably from Spain*" (Scuderi, 2015). Notwithstanding it is collocated in *Dendropoma* Mörch, 1861 by the presence of a complete operculum, which occupies all the entire aperture, the shell of young *D. gaederopi* could, in some ways, recalls that of the new species. It is sculptured by spiral chords, almost all equally marked, and robust axial ribs too. The lack of a complete operculum in the new species is useful for a quick distinction from *D. gaederopi*. The protoconch is different in general shape and sculpture. The external soft parts have a different colour pattern (Scuderi, 2015).

Protoconchs of the new species could be confused with those of some species of the genus *Petaloconchus* Lea, 1843, like the Indo-Pacific *P. cereus* Carpenter, 1857, the Mediterranean *P. laurae* Scuderi, 2012 or the European fossil *P. intortus* (Lamarck, 1818). They share with *V. bieleri* n. sp. a well-developed keel at the base but are less blunt and inflated in general outline. Another species of this latter genus, recently described for the Mediterranean, *P. laurae* Scuderi, 2012, is characterized by a protoconch with a single spiral chord at the base. But the latter has a more elongated general shape, different sculpture, a bigger nucleus (290 µm in *P. laurae* vs. 250 µm in *V. bieleri* n.sp.) and a surface covered by microscopic spiral lines. Moreover the first teleoconch whorl is sculptured by heavy ribs just in the early trait. Adult shells are very different.

Figures 1–9. *Vermetus bieleri* n. sp. Fig. 1: holotype, Funchal, Madeira, length 12.1 mm. Fig. 2: paratype 1, same data of holotype, length 21.4 mm (MMF). Fig. 3: paratype 6, Las Palmas, Gran Canaria, Playa del Hombre, length 22.0 mm (DSC). Fig. 4: paratype 7, same data of paratype 6, length 33.5 mm (FSC). Fig. 5: paratype 8, same data of paratype 6, length 25.1 mm (RBINS). Fig. 6: paratype 9, cluster of a ten of sh from Las Palmas, Gran Canaria, Playa del Hombre, length 38.0 mm, (RDPC). Fig. 7: shell of a not fully grown specimen, paratype 10, same data of paratype 6, length 14.0 mm, external Ø of the tube 3.1 mm (RBINS). Fig. 8: detail of the shell sculpture of a not fully grown specimen. Fig. 9: detail of the first tele-whorl, same data of paratype 6, length 1.2 mm, Ø of the tube 0.5 mm (DSC).



Figures 10–21. *Vermetus bieleri* n. sp. Funchal, Madeira. Figs. 10–11. SEM photographs of the protoconch and first tele-whorl, with detail of the basal chord (black arrow), same data of the specimen in figure 9, h 0.8 mm and w 0.7 mm (MNMS). Fig. 12: operculum, upper and lateral view; d 1.2 mm. Figs. 13–15: drawings of radular teeth: lateral tooth in frontal view (13), lateral tooth in upper view (14), rachidian (15). Fig. 16: phase-contrast photograph of two full grown embryos near to hatch, h 0.8 mm each. Fig. 17: photograph of an egg capsule containing eggs, h 4 mm. Fig. 18: photograph of an egg capsule containing embryos near to hatch, h 5 mm. Fig. 19: photograph of a single embryos, h 0.8 mm. Fig. 20: living specimens in their environment (magnification of a specimen in the upper-left corner). Fig. 21: drawing of the living animal, Ø of pedal disc 2.6 mm. Figure 22. *Vermetus triquetrus*. Drawing of the living animal, from Ganzirri, Messina (Sicily), length 16.5 mm, external Ø of the tube 4.0 mm (DSC).

DISCUSSION AND CONCLUSIONS

The genus *Vermetus* is currently insufficiently well characterised as an homogeneous group. It comprises a series of species which, on the basis of morphological differences, could be better assigned to different genera, representing a "genus-tank", which need a good modern definition. The new species is here grouped within *Vermetus* s. st. on the basis of analogies to the type species, *V. adansonii*, which had a troubled taxonomic history, resolved only in recent time (Keen, 1961). Moreover, the form and dimensions of the central and lateral radular tooth, which seem to have a good value in genus characterization (Scuderi, 2003), in the new species are of the same shape of those known for other similar congeners, i.e. *V. triquetrus*, *V. semisurrectus* or *V. granulatus*. Even some other anatomical characters, i.e. the presence of a reduced operculum on a semi-circular pedal disc, which constitutes the propodium, seem to state its relation to the typical *Vermetus* s. st. species.

The most similar species to *V. bieleri* n. sp. is the Mediterranean *V. triquetrus*. But this resemblance is limited to almost adult specimens, which share with the latter species similar shell sculpture. The protoconch is very distinct from that of all other species of *Vermetus*. When young, the shell of *V. bieleri* n. sp. is more similar in sculpture to another Mediterranean species, *V. granulatus*, which is smaller and have different protoconch and external soft parts.

Concerning maximum dimensions in length, width and diameter of the tube reached by the new species, our specimens seem bigger than those observed by Bieler (1995). The maximum dimensions of *V. bieleri* n. sp. are larger than those reported and personally observed in *V. triquetrus*.

Compared to the width of the foot, the operculum of *V. bieleri* n. sp. seem proportionally rather bigger than in *V. triquetrus*. Soft-body coloration is similar to that of some populations of *V. triquetrus*, although this latter is highly polymorphic in color too, ranging from almost black, with coloured dots and strips, to completely grey and yellow specimens (Scuderi, 2003).

The distribution of the new species seem limited to the Eastern Atlantic archipelagos and materials of the *V. triquetrus* studied from the Mediterranean confirm the absence of the new species inside this basin.

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REFERENCES

Bandel K., 1984. The radulae of Caribbean and other Mesogastropoda and Neogastropoda. Zoologische Verhandelingen, 214: 1–47.

Bieler R.,1995. Vermetids Gastropods from Sao Miguel, Azores: comparative anatomy, systematic position and biogeographic affiliation. Açoreana, supplement 173–192.

Calvo M. & Templado J., 2004. Reproduction and development in a vermetid gastropod, *Vermetus triquetrus*. Invertebrate Biology, 123: 289–303.

Keen A.M., 1961. A proposed reclassification of the gastropod family Vermetidae. Bulletin of the British Museum Natural History (Zoology), 7: 181–213.

Lacaze-Duthiers H., 1860. Memoire sur l'Anatomie et l'Embryologie des Vermets (*Vermetus triqueter* et *V. semisurrectus* Phil.). Annales des Sciences Naturelles, Zoologie, 13: 209–296.

Monterosato T. di Maria di, 1892. Monografia dei Vermeti del Mediterraneo. Bullettino della Società malacologica italiana, 17: 7–48.

Morton J.E., 1965. Form and function in the evolution of the Vermetidae. Bullettin of the British Museum (Natural History), London, 2: 585–630.

Nordsieck F. & F. Garcia-Talavera, 1979. Moluscos marinos de Canarias y Madera (Gastropoda). Aula de Cultura, Tenerife, 208 pp.

Schiaparelli S., 1996. Contributions to the knowledge of Vermetidae (Mollusca, Gastropoda) from the Ligurian Sea. Bollettino Malacologico, 31: 267–276.

Scuderi D., 1999. Contributo alla conoscenza dei Vermetidae mediterranei: *Vermetus granulatus* (Gravenhorst, 1831) e suoi principali morfotipi. Bollettino Malacologico, 35: 45–48.

Scuderi D., 2003. Implicazioni sistematico-evolutive della biologia e dell'ecologia dei Vermetidae. PhD thesis: 131 pp., 9 plates.

Scuderi D., 2015. On the rediscovery of the vermetid "*Siphonium*" *gaederopi* Mörch, 1861 (Gastropoda Vermetidæ) with systematic and ecological observations on the early juveniles stages. Biodiversity Journal, 6: 365–370.

Segers W., Swinnen F. & De Prins R., 2009. Marine molluscs of Madeira. Madeira and Selvagens Archipelago. R. De Prins Ed., 612 pp.

Talavera F.G., 1978. Moluscos marinos de las Islas Salvajes. In: Contribución al estudio de la historia natural de las Islas Salvajes. Aula de Cultura de Tenerife, p. 119–128, 1 pl.

Via S., Gomulkiewicz R., De Jong G., Scheiner S.M., Schlichting C.D. & van Tienderen P.H., 1995. Adaptive phenotipic plasticity: consensus and controversy. Trend in Ecology and Evolution, 10: 212–217.

Watson R.B., 1897. On the marine mollusca of Madeira; with descriptions of thirty-five new species, and an index-list of all the known sea-dwelling species of that island. Journal of the Linnean Society of London, Zoology, 26: 233–329.

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From the estuary to the Amazon basin: *Corbicula fluminea* (O.F. Müller, 1774) (Bivalvia Venerida Cyrenidae) in Ecuador

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ABSTRACT The Asian clam *Corbicula fluminea* (O.F. Müller, 1774) (Bivalvia Venerida Cyrenidae) is a non-indigenous invasive species with a vast record of new occurrences worldwide. The salinity and thermal tolerance of the clam led us to look for evidences on the presence of *C. fluminea* in the Guayas Estuary, Ecuador. The inspection of the upper estuary confirmed our hypothesis. Fresh remains of the clam, along with degraded shells and different shell class sizes (14.62±2.67 mm, mean shell length) were observed. It was concluded that this estuary corresponds most likely to the introduction of *C. fluminea* in Ecuador. Its occurrence at the upper Amazon basin is attributed to a human mediated introduction linked to the trading use of the clam.

KEY WORDS Ballast water; Ecuador; human mediated; invasibility; invasiveness.

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INTRODUCTION

The Asian clam *Corbicula fluminea* (O.F. Müller, 1774) (Bivalvia Venerida Cyrenidae) is a highly invasive species (McMahon, 1999). Its native distribution range is thought to extend from eastern Asia (reaching the north in eastern Russia and the Philippines in the South, including China, the Korean Peninsula as well as Japan (Karatayev et al., 2007). As a result of its invasive potential, the species occurs now in all the continents except the Antarctic (Gama et al., 2016). The invasive occurrence of *C. fluminea* in South America is not so overwhelmingly present as in Europe or North America, but the information about its distribution range in South America is somewhat contradictory. Some published data situate *C. fluminea* exclusively at the east of the Andean Cordillera (Gama et al., 2016) while others authors locate populations of the clam between the Cordillera and the Pacific Ocean (Crespo et al., 2015).

The spreading of *C. fluminea* in estuaries and freshwater ecosystems depends on key environmental parameters such as salinity, temperature and oxygen concentration values. The species is able to inhabit estuarine environments but it is rarely observed beyond the oligohaline zone, with a reported maximum of 17 psu (Verbrugge et al., 2012) in which its survival may be compromised (Morton & Tong, 1985). Verbrugge et al. (2012) limit the thermal tolerance of the Asian clam at 37 °C, while Crespo et al. (2015) provide information on thermal survivorship within the range 2–34.8 °C. This clam has low tolerance to reduced dissolved oxygen conditions, especially adult individuals (Matthews & McMahon, 1999). Values of 3% in oxygen saturation during more than a week may cause a significant increase in mortality

(Matthews & McMahon, 1999). Besides, adequate concentrations of calcium and satisfactory pH values are also important for the establishment of *C. fluminea* populations (Cooper, 2007). Decimated population may recover easily or isolated individuals may found new populations because *Corbicula* Megerle von Mühlfeld, 1811 specimens have high reproductive capacity and plasticity undergoing hermaphroditic, cross-fertilization and self-fertilization (McMahon, 1999; Lee et al., 2005).

Ballast water discharge, shellfish transplantation and intentional releases are frequently reported among the most common vectors for aquatic species introductions (Roman & Darling, 2007). The completion of an aquatic invasion depends on a number of factors such as vector dynamics at the origin and destination points, species endurance during transport, the existence of advantageous environmental or biological conditions in favor of an invasive species or even the invasive susceptibility of a habitat. For instance, large ports receiving transoceanic ships facilitate the introduction of invasive species because of the increased risk of ballast waters discharge (Keller et al., 2011). In the same vein, species adapted to dynamic environments may become more easily established in destination habitats than species with lesser physiological plasticity (Davis, 2009; Liu et al., 2012). Species invasiveness may be also enhanced or limited by biological interactions such as, for instance, predator-prey dynamics (Hunt & Yamada, 2003). Invasive species could additionally benefit from their edible features to spread further: unrestricted harvesting of introduced species for human consumption may create the temptation to introduce the species to uninvaded regions as an economic resource (Nuñez et al., 2012).

The aim of this study was to find evidences of the occurrence of *C. fluminea* in the largest estuarine system in Ecuador, the Guayas estuary. This work also intends to clarify the introduction of the clam in the country and advance the most likely pathway followed by the Asian clam to reach the upper Amazon basin.

MATERIAL AND METHODS

Study area

The Mocolí Island is located in the upper Guayas estuary, where the Babahoyo River flows into the estuary (Fig. 1). The study site is not far from the port of Guayaquil. The port has been historically located in the Guayas estuary, but new port terminals were builded in a nearby creek interconnected with the estuary. The Mocolí Island has a surface of 295.4 hectares and it is used as a residential area. The island is mainly a private property and access to the intertidal area is very difficult or even forbidden for government's officials. This situation is recurrent in the upper estuary where real estate businesses own properties around the margins of the estuary. Our first plan was to inspect parts of the Island where access to the shore was easily granted. However, guards stopped us in our way and we were directed to the property managers. After meeting with a number of managers by more than an hour and a half, access was finally granted to part of the intertidal zone nearby the bridge that connect the Island with the mainland (02°06'09.88''S, 079°52'05.60''W; Fig. 1).

Sampling, lab procedures and data analysis

Sampling was carried out, during ebb tide, at the beginning of February 2017. The mid height of the intertidal region was inspected within a surface of approximately 75 m^2 during 30 min by three people. All the retrieved sampled elements were stored in 70% alcohol solution. Next, 150 m of the upper intertidal region were inspected in the opposite direction of the bridge during 20 min by four people, when the tide prevented continuing the survey in the mid intertidal. Many debris brought by currents and tides were present in this zone, including dead clams. Water samples were collected to measure salinity in the lab and water temperature was measured in situ with a digital thermometer (almost at noon).

Shell length was measured in the right valve, with a Vernier caliper, to the nearest 0.01 mm. Salinity was measured optically in the lab with a refractometer. Shells were washed up and opened to look for living specimens. Pictures were taken to highlight key features of the sampled individuals. Shell's class sizes were displayed in a histogram with 1mm bin's width. The mean and standard deviation of shells with a normal distribution were de-

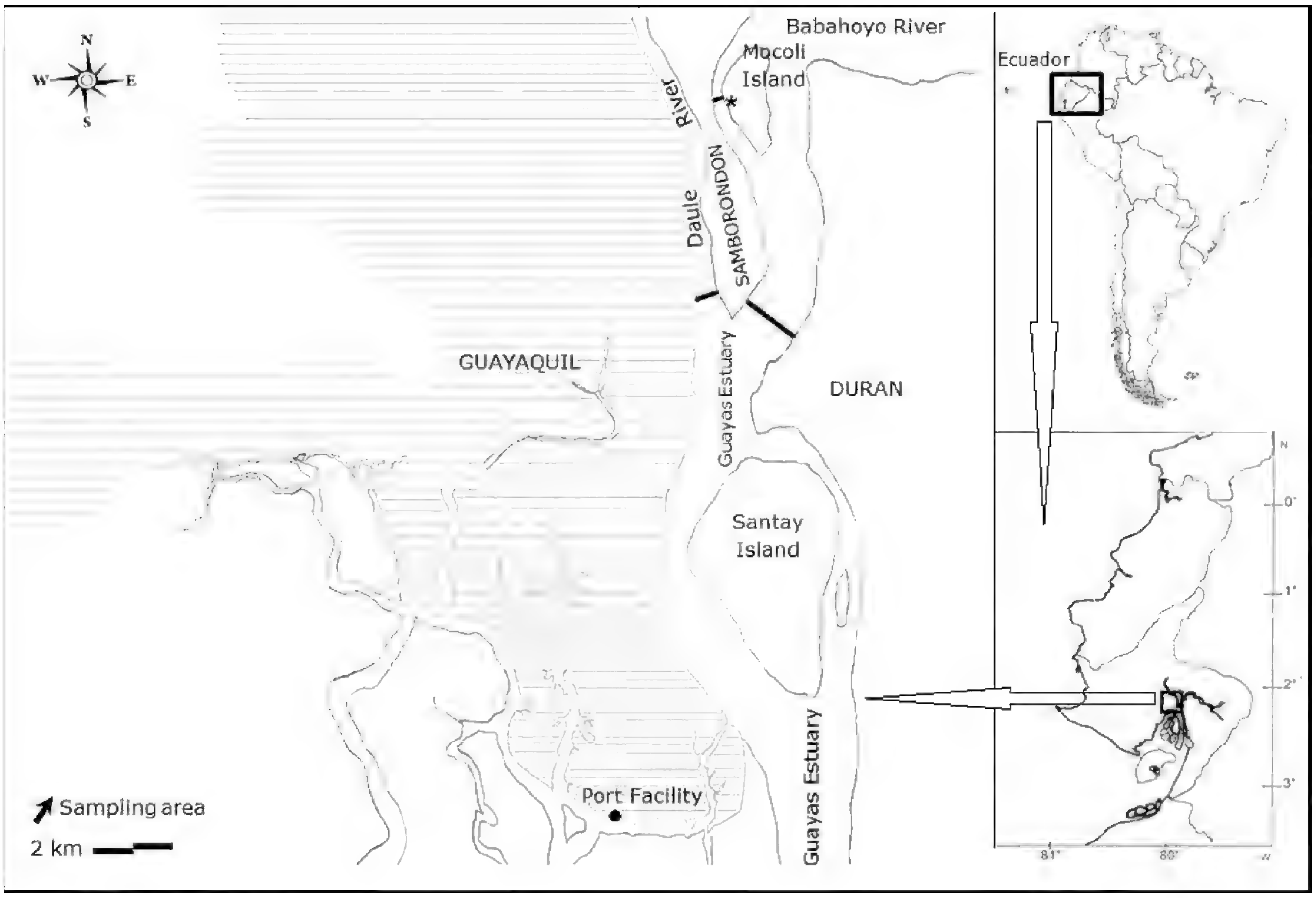
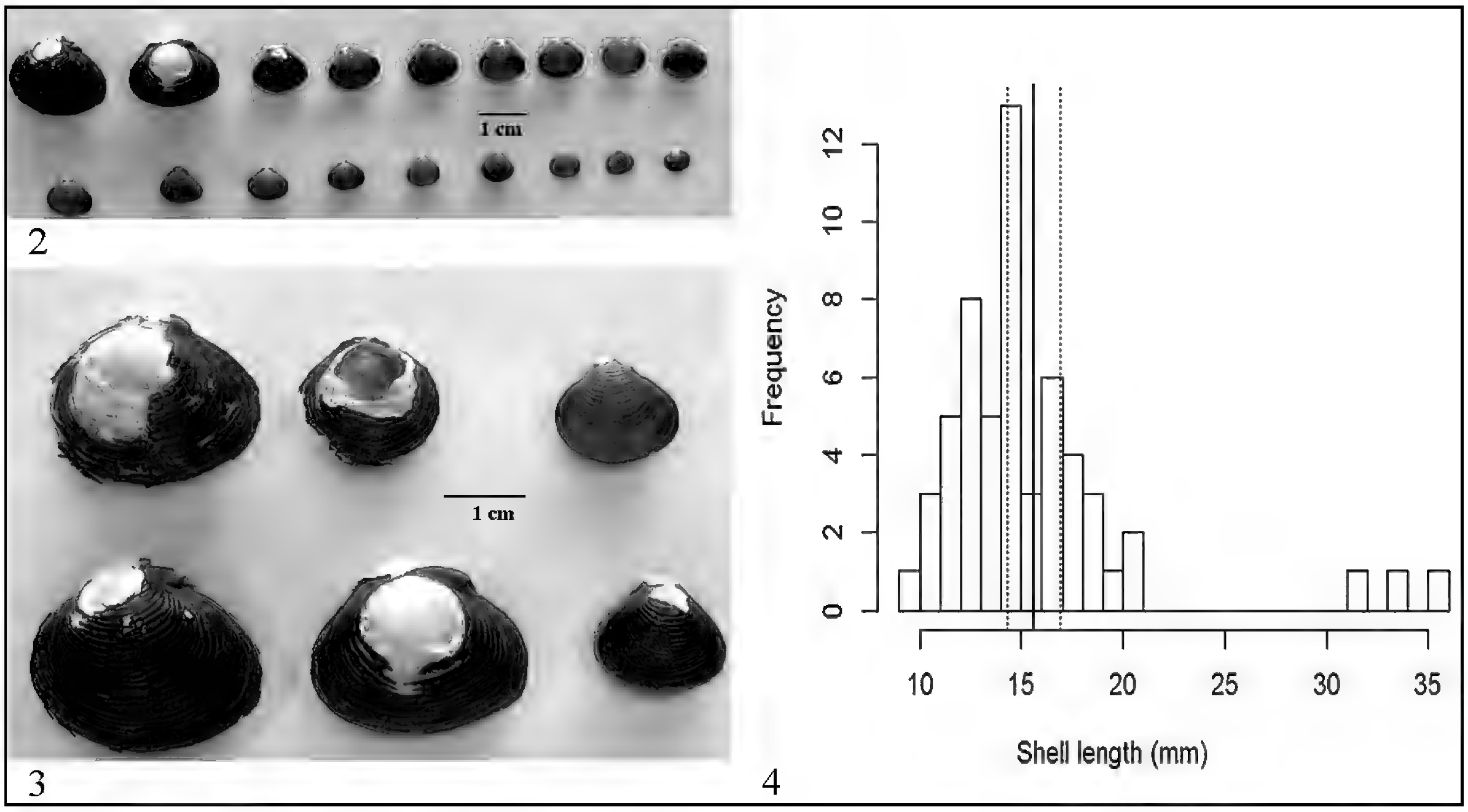


Figure 1. Map showing the study site and the location of the Port of Guayaquil in relation to the Guayas estuary. Gross dark lines over the estuary are bridges. The striped area represents the city of Guayaquil.

Location	Coordinates	References	Survey
Pastaza River	2°21’33”S, 77°05’03”W	Willink et al., 2005	1999
Pastaza River	1°55’09”S, 77°48’52”W	Lee et al., 2005	1999
Pastaza River	2°14’09”S, 77°15’10”W	Lee et al., 2005	1999
Esmeraldas River	0°55’01”N, 79°39’17”W	INP, 2002	2001
Taura River Basin	2°18’00”S, 79°43’60”W	Mora, 2005	2005
Taura River Basin	2°15’26”S, 79°22’12”W	Mora, 2005	2005
Baba River Basin	0°29’37”S, 79°19’21”W	Cárdenas, 2011	2010-2011
Baba River Basin	1°01’02”S, 79°27’49”W	Cárdenas, 2011	2010-2011
Los Rios Province	1°20’43”S, 79°22’33”W	Muzzio, 2011	Before 2011
Los Rios Province	1°47’43”S, 79°18’05”W	Muzzio, 2011	Before 2011
Los Rios Province	1°40’26”S, 79°38’54”W	Muzzio, 2011	Before 2011
Búa River	0°04’14”S, 79°26’32”W	Muzzio, 2011	Before 2011
Isla Mocoli	2°06’10”S, 79°51’41”W	This study	2017

Table 1. Locations, coordinates, references and dates of the survey at study sites where the occurrence of *Corbicula fluminea* was reported in Ecuador.



Figures 2, 3. Photographs showing (Fig. 2) the whole set of shell's sizes collected at the sampling site and (Fig. 3) state of conservation of the shells. Figure 4. Histogram showing shell length frequencies at bins of 1 mm. The dark vertical line is coincident with the mean length of the whole set of shells after excluding the three shells located at the right side of the histogram. Vertical discontinuous lines represent the standard deviation.

picted in the histogram. Normality was assessed with a Shapiro test (Crawley, 2007). The Chebyshev's inequality was used to calculate the proportion of the population at a distance of k standard deviations from the mean (Beasley et al., 2004). The Chebyshev's inequality is a conservative approach that may be applied to any distribution type (Beasley et al., 2004). Data analysis was carried out using R statistical software. The systematic follows WoRMS (2017).

RESULTS

The mean salinity in the study site was between 0-0.5 psu and mean temperature 26.8±0 °C. None of the shells collected corresponded with a living clam. However, fourteen shells were observed in living position at the study site, indicating that the clams settled, lived and died in the sampling area at the upper reaches of the Guayas estuary. Shell´s morphology match the expected features for *C. fluminea,* though the taxonomy of the genus *Corbicula* is a matter of controversy and debate (Lee et al., 2005). The whole set of shell's sizes is shown in figure 2. The picture includes 18 out of 57 collected shells. The largest shell had a length of 35.23 mm and the smallest 9.48 mm. The state of conservation of the shells (Fig. 3) indicates that the time of death was not the same for all the clams. Overall, the information provided by figure 2 suggest that not all the collected shells belong to the same reproductive event.

The existence of at least two clam cohorts is well represented in the histogram shown in figure 3 (the whole set of shell were included). There is a big gap between the shells in the left side of the histogram and the shells in the right side. The whole set of shells do not have a normal distribution (Shapiro test, $W = 0.741$, $p<0.001$) but the population is normally distributed when shells in the right side of the histogram are not considered (Shapiro test, $W = 0.975$, $p= 0.307$). The mean and the standard deviation (14.62±2.67 mm) for the population of clams with a normal distribution are shown in the histogram (Fig. 4). The smallest shell

in the group located in the right side of the histogram has a length of 31.73 mm, or k=6.41 standard deviations from the shell's length mean in the left side of the histogram. K was obtained after solving the equation: mean + k (standard deviations) = 31.73. In accordance to the Chebyshev's inequality, six standard deviations should include 97% of the population (Beasley et al., 2004). If this proportion is thought as likelihood, then the probability of belonging to a population of shells with a mean length of 14.62 mm for a shell with 31.73 mm length would be less than 0.03**%**. Thus, differentiate reproductive events emerge again, indicating that *C. fluminea* has reproductive populations in the Guayas estuary.

DISCUSSION

The Asian clam *C. fluminea* was able to colonize the oligohaline portion of the Guayas estuary. The clam has also the capacity to reproduce in the estuary, though their populations demonstrate to be vulnerable in this environment. Concurrently, we did not find living specimens, but the collections of shell in living position prove the ability of the clam to establish populations within the estuary. Collection of shells in living position has been used to characterize and study clam populations in sampling sites (Palacios et al., 2000; Conde et al., 2012). The shell size range indicates that most of the clams were likely within their first year at the time of death, except the three larger individuals (Cataldo & Boltovskoy, 1998; Fig. 4). Brown et al., (2007) found reproductive individuals within the shell size range 6–10 mm (see also McMahon, 1999), strongly suggesting that the clams in this study were able to reproduce before dying. Additionally, the different conservation state of the retrieved shells suggests that not all the clams belonged to the same generation. Thereby, the ability of the clam to reproduce in the Guayas estuary seems to be very likely.

Corbicula fluminea was probably transported from North America to Ecuador rather than from eastern South America (Crespo et al., 2015) because of the proximity of ports and the higher number of donor areas in western North America. The largest commercial port in Ecuador is located in the Guayas estuary (Fig. 1) emerging as the most likely recipient of marine vectors transporting the clam (merchant ships; Roman & Darling, 2007; Keller et al., 2011). The morphotype Form A described for the Ecuadorian *Corbicula* in Lee et al. (2005) is frequent in North America with only one record in Argentina, at the south of the continent. The introduction of *C. fluminea* in the Guayas estuary may be explained by the release of individuals from bilge or ballast water. Additionally, the invasibility of oligohaline zones in estuaries may facilitate the occurrence of the Asian clam. This estuarine region in the marine-riverine confluence provides a suitable environment, since it is not generally limited by food resources and few predators may cope with saline stress (preconditions highlighted by Davis, 2009). Conversely, *C. fluminea* can osmoregulate at salinities below 13 psu, with little mortality for at least 7 days (Morton & Tong, 1985) or even establishing permanent populations in oligohaline estuarine zones

Figure 5. Fisherman showing a partial catchment of *Corbicula fluminea* inside a net used to gather clams. *C. fluminea* is caught by diving before being brought on board within the net. Note that the fisherman stands over a larger catchment already stored at the bottom of his boat.

(Conde et al., 2013). Once established in an estuary, the clam is prone to spread further. Tidal currents allow the clam to dislodge upstream or downstream. To do so, small individuals of *C. fluminea* secrete long mucous threads through their exhalent siphons in order to be transported by currents (Prezant & Chalermwat, 1984). Additional vectors of dispersal have been pointed out such as local pedal locomotion, entanglement with drifting plant (water hyacinth is a drifting plant in the Guayas estuary), carriage by birds, angling, commercial fishing, fish stocking or dredging among others (Karatayev et al., 2007; Roman & Darling, 2007; Minchin, 2014).

Gama et al. (2016) did not include Ecuador as a world's known location where the Asian clam has been reported, though previously, Crespo et al., (2015) referred the occurrence of the Asian clam in the country. The latter authors provide both mean and maximum shell length in relation to latitude and temperature that approach the values described in this study. Moreover, the presence of the clam in Ecuador led us to look for more detailed information, including grey literature. The outcome of this search revealed that the distribution of the clam, rather than occasional or localized (Crespo et al., 2015) is widespread from north to south in watersheds at the west of the Andean Cordillera (Table 1). Cárdenas (2013) even reported the clam as a fishery for human consumption and also refers the selling of *C. fluminea* in local markets. Indeed, the fishery of the clam in Ecuador has been documented by our institution in the Baba River (Fig. 5).

The exploitation of *C. fluminea* as a commercial valuable species in Ecuador may clarify the main raison for its widespread distribution in the country. Moreover, this tradable feature of the clam may elucidate its introduction to the east of the Andean Cordillera (Crespo et al., 2015) at the Pastaza River, Amazon basin (including Ecuador and Peru; Lee et al., 2005). Though Lee et al. (2005) referred only to the genus *Corbicula*, most likely the collected individuals from the Pastaza River pertained to the same species as the one describe in this study. A human mediated introduction from the western to the eastern Andes emerges as a necessary transport vector to overpass this natural barrier with a mean height of 4000 meters. The Asian clam has been previously described as upstream as in Manaus, lower Amazon (Beasley et al., 2003) in the west of the Amazon basin. We hypothesize that the long way from the Pastaza River to Manaus is highly susceptible of being colonized by *C. fluminea*. The clam may benefit from the downstream current along with its dispersion capabilities, an edible reputation and a high biological plasticity (Lee et al., 2005). If the clam was able to cross the Andean Cordillera, the allegedly high autochthonous aquatic diversity and the anoxic waters in the Amazon basin (Crespo et al., 2015 and reference therein) seem to be minor barriers to the dispersal of the clam towards the west. A follow up of the invasion in the Amazon basin for ecosystem conservation purposes would be advisable.

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REFERENCES

Beasley C.R., Tagliaro C.H. & Figueiredo W.B., 2003. The occurrence of the Asian clam *Corbicula fluminea* in the Lower Amazon Basin. Acta Amazonica, 33: 317–324.

Beasley T., Page G., Brand J., Gadbury G., Mountz J. & Allison D., 2004. Chebyshev's inequality for non-parametric testing with small N and α in microarray research. Journal of the Royal Statistical Society Series C–Applied Statistics, 53: 95–108.

Brown L.R., Thompson J.K., Higgins K. & Lucas L.V., 2007. Population density, biomass, and age-class structure of the invasive clam *Corbicula fluminea* in rivers of the lower San Joaquin river watershed, California. Western North American Naturalist, 67: 572–586.

Cárdenas M., 2011. Estructura comunitaria de macroinvertebrados en el río Baba durante julio de 2010 a

julio de 2011. Instituto Nacional de Pesca, Guayaquil, 76 pp.

Cárdenas M., 2013. Calidad de las aguas de los cuerpos hídricos de la provincia del Guayas mediante el uso de macroinvertebrados acuáticos registrados durante noviembre de 2012 y marzo de 2013. Prefectura del Guayas, Guayaquil, 86 pp.

Cataldo D. & Boltovskoy D., 1998. Population dynamics of *Corbicula fluminea* (Bivalvia) in the Parana River Delta (Argentina). Hydrobiologia, 380: 153–163.

Conde A., Novais J. & Domínguez J., 2012. The presence of *Mya arenaria* in the Ria de Aveiro is the third confirmed record of this invasive clam on the Portuguese coast. Marine Biodiversity Records, 5: doi:10.1017/S1755267212000784.

Conde A., Novais J. & Domínguez J., 2013. Multivariate analysis applied to agglomerated macrobenthic data from an unpolluted estuary. Marine Environmental Research, 87–88: 112–121.

Cooper J.E., 2007. *Corbicula fluminea* (Asian clam) in the Roanoke River, North Carolina: A Stressed Population? Southeastern Naturalist, 6: 413–434.

Crawley M.J., 2007. The R Book. John Wiley & Sons, Chichester, 942 pp.

Crespo D., Dolbeth M., Leston S., Sousa R. & Pardal M.A., 2015. Distribution of *Corbicula fluminea* (Müller, 1774) in the invaded range: a geographic approach with notes on species traits variability. Biological Invasions, 17: 2087–2101.

Davis M.A., 2009. Invasion Biology. Oxford University Press, Oxford, 288 pp.

Gama M., Crespo D., Dolbeth M. & Anastácio P., 2016. Predicting global habitat suitability for *Corbicula fluminea* using species distribution models: The importance of different environmental datasets. Ecological Modelling, 319: 163–169.

Hunt C.E. & Yamada S.B., 2003. Biotic resistance experienced by an invasive crustacean in a temperate estuary. Biological Invasions, 5: 33–43.

INP, 2002. Características biológica, pesqueras y socio ambientales en el ecosistema del río Esmeraldas y aguas aledañas durante el 2001. Instituto Nacional de Pesca, Guayaquil, 262 pp.

Karatayev A.Y., Padilla D.K., Minchin D., Boltovskoy D. & Burlakova L.E., 2007. Changes in global economies and trade: the potential spread of exotic freshwater bivalves. Biological Invasions, 9: 161–180.

Keller R., Drake J., Drew M. & Lodge D., 2011. Linking environmental conditions and ship movements to estimate invasive species transport across the global shipping network. Diversity and Distributions, 17: 93–102.

Lee T., Siripattrawan S., Ituarte C.F. & O'Foighil D., 2005. Invasion of the clonal clams: *Corbicula* lineages in the New World. American Malacological Bulletin, 20: 113–122.

Liu G., Huang Q.Q., Lin Z.G., Huang F.F., Liao H.X. & Peng S.L., 2012. High tolerance to salinity and herbivory stresses may explain the expansion of Ipomoea cairica to salt marshes. PLoS ONE, 7: e48829. doi:10.1371/journal.pone.0048829.

Matthews M.A. & McMahon R.F., 1999. Effects of temperature and temperature acclimation on survival of zebra mussels (*Dreissena polymorpha*) and Asian clams (*Corbicula fluminea*) under extreme hypoxia. Journal of Molluscan Studies, 65: 317–325.

McMahon R.F., 1999. Invasive characteristics of the freshwater bivalve, *Corbicula fluminea*. In: Claudi R. & Leach J.H., 1999, Nonindigenous freshwater organisms: Vectors, biology and impacts. CRC Press, Boca Raton, 315–343.

Minchin D., 2014. The distribution of the Asian clam *Corbicula fluminea* and its potential to spread in Ireland. Management of Biological Invasions, 5: 165–177.

Mora E., 2005. Bioensayos en Moluscos: Bioensayos de toxicidad aguda con cadmio en la especie Almeja de río *Corbicula* sp., de la Cuenca del Río Taura. Ciencias Naturales y Ambientales, 1:141–146.

Morton B. & Tong K.Y., 1985. The salinity tolerance of *Corbicula fluminea* (Bivalvia: Corbiculidea) from Hong Kong. Malacological Review, 18: 91–95.

Muzzio J.K., 2011. Moluscos hospederos intermediarios de *Angiostrongylus cantonensis* en dos provincias de Ecuador. Instituto de Medicina Tropical "Pedro Kouri", La Habana, 42 pp.

Nuñez M.A., Kuebbing S., Dimarco R.D. & Simberloff D., 2012. Invasive species: to eat or not to eat, that is the question. Conservation Letters, 5: 334–341.

Palacios R., Armstrong D.A. & Orensanz J., 2000. Fate and legacy of an invasion: extinct and extant populations of the soft-shell clam (*Mya arenaria*) in Grays Harbor (Washington). Aquatic Conservation: Marine and Freshwater Ecosystems, 10: 279–303.

Prezant R.S. & Chalermwat K., 1984. Flotation of the bivalve *Corbicula fluminea* as a means of dispersal. Science, 225: 1491–1493.

Roman J. & Darling J.A., 2007. Paradox lost: genetic diversity and the success of aquatic invasions. Trends in Ecology and Evolution, 22: 454–464.

Verbrugge L.N.H., Schipper A.M., Huijbregts M.A.J., Van der Velde G. & Leuven R.S.E.W., 2012. Sensitivity of native and non-native mollusc species to changing river water temperature and salinity. Biological Invasions, 14: 1187–1199.

Willink P.W., Chernoff B. & McCullough J., 2005. A Rapid Biological Assessment of the Aquatic Ecosystems of the Pastaza River Basin, Ecuador

and Perú. Conservation International, Washington, 250 pp.

WoRMS - World Register of Marine Species, 2017. http://www.marinespecies.org/aphia.php?p=taxdetails&id=138439 last date of consultation: 26.10.2017.

Biodiversity Journal, 2017, 8 (4): 923–926

Report on first record on the occurrence of *Geastrum* Pers. (Geastrales Geastraceae) in Western Ghats forests in Goa (India)

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ABSTRACT The species of genus *Geastrum* Pers. belonging to Basidiomycotina (Geastrales Geastraceae) is observed and reported in this paper for the first time. The Cotigao Wildlife Sanctuary in Western Ghat forest, Goa (India) has been examined by the author thoroughly on a monthly basis to collect samples of microfungi. This is the first instance wherein the earthstars have showed their presence by formation of minute fruiting bodies. Hence it is reported for the first time as new records to this part of the Western Ghats forest as one of the hotspots in the world.

KEY WORDS *Geastrum*; Western Ghats; forests; biodiversity.

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INTRODUCTION

Geastrum Pers. is a genus of mushroom belonging to the Basidiomycotina, which is currently placed in the order Geatrales and in the Geastraceae family (Hosaka & Castellano, 2008). This genus is well distributed geographically, with approximately 50 known species around the world (Kirk et al., 2008). Many species of *Geastrum* are commonly called "Earthstars". This common name refers to the outer layer of the fruiting body, the exoperidium, that, when mature, splits into segments which turn outward creating a star-like pattern on the ground.

According to the Index Fungorum (2017), the widely used fungal database, so far, around 334 records of *Geastrum* have been reported from all over the world. There is a large number of studies that have focused on the different species of the *Geastrum* both in tropical and temperate countries (Demoulin, 1984; Douanla-Meli et al., 2005; Fazolino et al., 2008; Silva & Baseia, 2013; Zamora et al., 2015).

Below we report the first record of the smallest known, so far, *Geastrum* species from the Cotigao Wildlife Sanctuary in Western Ghat forest, Goa (India).

MATERIAL AND METHODS

On 11th October 2011, during our regular field sampling of plant for microfungi in the Western Ghat forest in Cotigao Wildlife Sanctuary, Canacona, South Goa, India (14°58'43.17"N, 74°8'56.75"E), a very unusual earthstar was encountered measuring 0.5–0.7 mm in diameter, caught the attention of the author who was also ac-

Figure 1. Study area: Western Ghat forest in Cotigao Wildlife Sanctuary, Canacona, South Goa, India. Figures 2, 3. Western Ghat forest. Figure 4. *Geastrum* sp. from the study area.

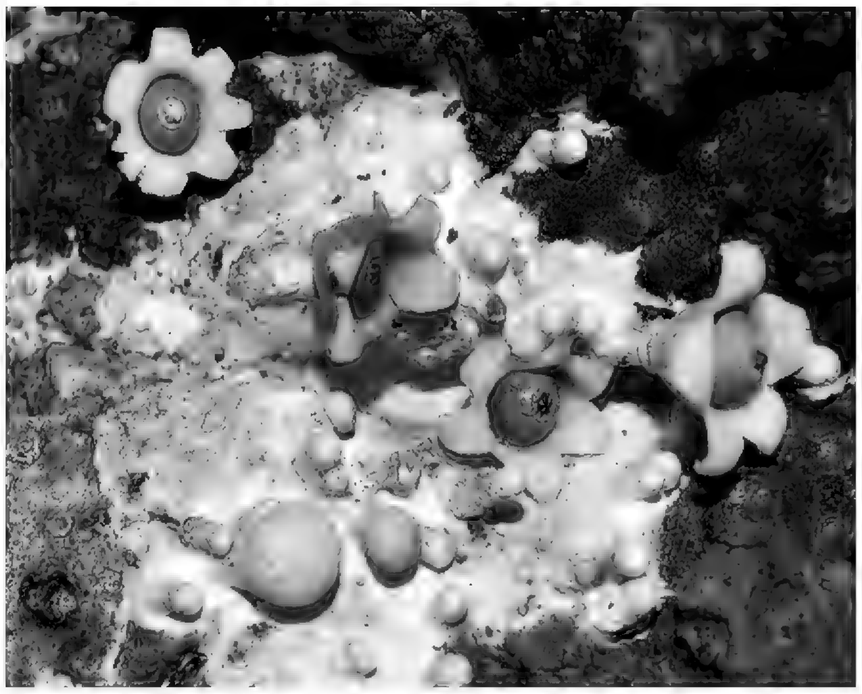

Figure 5. *Geastrum* sp. from Western Ghat forest in Cotigao Wildlife Sanctuary, Canacona, South Goa, India.

companying students during the field sampling (Figs. 1–5). The Cotigao Wildlife Sanctuary, Goa, is located 10 km south-east of Chaudi and was established in 1969 to protect a vulnerable area of the forest in the Goa-Karnataka border.

Earth stars as the *Geastrum* species are not so widely distributed in Goa and shows intermittent appearance when the environmental conditions are favourable. This small size earthstar was found at the base of the trunk of a tree in the crevices and initially, at a distance, it looked like a small flowers at the base of the tree trunk i.e. *Hydnocarpus laurifolia* (Dennst.) Sleumer (Achariaceae) but upon close examination, it was discovered to be the earth star, a species of *Geastrum*. The forest was mostly dominated by trees such as *H. laurifolia*, *Holygarna sp.* (Anacardiaceae), *Psychotria dalzellii* Hook. f. (Rubiaceae), *Terminalia tomentosa* Wight et Arn. (Combretaceae), *Dellenia indica* L. (Dilleniaceae), and was of wet deciduous type. It was carefully collected in polythene bags trying to avoid damage to the specimen as much as possible and brought to the laboratory. Later, we tried to culture the microorganism in the laboratory. Since most of these basidomycetes are ectomycorrhizal and usually come up with a shower of monsoon or at the end of the monsoon when the showers are fewer. As such, we failed to culture the organism in vitro conditions in laboratory. We need to compile more records and thorough studies on its morphological features as well as on its molecular taxonomy in order to consider it and deem it as a new species.

To my knowledge, this is the first scientific documentation of an occurrence of *Geastrum* sp. of such small dimension from this part of the region in Goa, India. Although detailed studies are essential on the culturing of the fungus and to determine its complete identity, the occurrence of such a small species of *Geastrum* is sufficient to call attention of researchers to take the necessary steps to study and preserve such macrofungi in situ as well as to further use these organisms. This is of particular importance, as the Western Ghats is one of the biodiversity hotspots in India harbouring a wide variety of species of fungi and more species are yet to be discovered and recorded from this part of the region.

The reason for me to share this experience is that such species can also be encountered in a densely populated forest such a Cotigao. We only need to have an eye for such specimens to try to discover and record more.

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REFERENCES

Douanla-Meli C., Langer E. & Calonge F.D., 2005. *Geastrum pleosporus* sp. nov., a new species of Geastraceae identified by morphological and molecular phylogenetic data. Mycological Progress, 4: 239–250. doi:10.1007/s11557-006-0127-3.

Demoulin V., 1984. Typification of *Geastrum* Pers.: Pers. and its orthographic variant Geaster (Gasteromycetes). Taxon, 33: 498–501.

Fazolino E.P., Calonge F.D. & Baseia I.G., 2008. *Geastrum entomophilum*, a new earthstar with an unusual spore dispersal strategy. Mycotaxon, 104: 449–53.

Hosaka K. & Castellano M.A., 2008. Molecular phylogenetics of Geastrales with special emphasis on the position of *Sclerogaster*. Bulletin of the Nationale Museum of Nature and Science, 34: 161–173.

Index Fungorum, 2017. http://www.indexfungorum.org/; last accessed 19.X.2017

Kirk P.M., Cannon P.F., David J.C. & Stalpers J.A., 2008. Ainsworth & Bisby's Dictionary of the fungi. 10th edition, CAB International, Wallingford, 784 pp.

Silva B.D.B., Cabral T.S., Marinho P., Ishikawa N.K. & Baseia I.G., 2013. Two new species of *Geastrum* (Geastraceae, Basidiomycota) found in Brazil. Nova Hedwigia, 96: 445–456

Zamora J.C., Calonge F.D. & Martin M.P., 2015. Integrative taxonomy reveals an unexpected diversity in *Geastrum* section *Geastrum* (Geastrales, Basidiomycota). Persoonia, 34: 130–165.

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A new species of the genus *Milax* Ellis, 1926 (Gastropoda Pulmonata, Milacidae) from Lampedusa Island (Sicilian Channel, Italy)

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ABSTRACT

Milax lopadusanus n. sp. (Gastropoda Pulmonata Milacidae) is described from Lampedusa Island, the biggest of the islands of the Pelagie Archipelago (Sicilian Channel, Italy). The new species is characterized by: greyish-brown body, with distinct yellowish keel; conical, smooth stimulator, with a raised crest along one side and spermatophore characterized by conic anterior part, covered on one side by bifurcated spines with the two apexes thorny; posterior part cylindrical, covered by smaller and most dense spines on all sides. Additional faunistic, biological and taxonomical notes are provided.

KEY WORDS New slug; morphology; taxonomy; systematics.

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INTRODUCTION

The slug genus *Milax* Ellis, 1926 (Gastropoda Pulmonata Milacidae) has Euro-Mediterranean-Caucasian distribution. In Italy two *Milax* species are reported: *M. nigricans* (Philippi, 1836) with a Western Mediterranean and Western European distribution and *M. gagates* (Draparnaud, 1801) only found in Sardinia and Sicily, which occurs as well in Western Europe, Western Mediterranean and Canary Islands, (Wiktor, 1987a; Manganelli et al., 1995; Bank, 2017).

In North Africa, in addition to *M. nigricans* and *M. gagates*, two more species were so far reported: *M. gasulli* Altena, 1974 endemic of northeastern Tunisia and *M. ater* (Collinge, 1895) endemic of northern Algeria. These four species are very similar in external characters of the black or greyish body and such a strong resemblance led to confusion where they coexist. Nevertheless, they are well distinguishable once dissected, i.e. by the shape of the genitalia and the spermatophore.

The genus *Milax* was reported for Lampedusa Island (Pelagie Archipelago, Sicilian Channel, Italy) by Alzona (1961) who mentioned *M. gagates* and by Beckmann (1992, 1998) and Cianfanelli (2002) that reported *M. nigricans*, however no description or illustration of genitalia was provided by these authors.

Lampedusa Island is 20.2 Km^2 wide and is 195 Km far from the Sicilian coast and 120 Km from Tunisia. Lampedusa is an emerged portion of the

African Continental shelf and it consists of a succession of limestone-dolomite rocks of the upper Miocene age.

The absence of Pliocene and Pleistocene marine sediments suggested that it was emerged for a very long time; marine deposits of Tyrrhenian age are present, on limited extensions, only on the eastern side of Lampedusa (Grasso & Pedley, 1985). It is, therefore, of ancient origin and it has been connected to African continent during the glaciations (Burgio & Catalisano, 1994).

The research activities carried out on this island and the morphological analysis of the collected *Milax* specimens allowed us on one hand to confirm the presence of *M. nigricans* and on the other to ascertain the presence of a second species with a set of characters which have never been previously observed in other representatives of the genus. Thanks to these result a new species is here described.

MATERIAL AND METHODS

All specimens were collected by eye-sight on the ground and under rocks, preferably at night but also in daylight. Four specimens were bred in captivity from October 2017 to November 2017. In the laboratory they were normally kept in plastic boxes containing ground, limestone rocks and lettuce or carrot. Observations on ecology of these slugs were made both directly in the field and in laboratory. The specimens were studied as regards size, colour, external morphology and morphology of genitalia. Photographs were taken with a digital camera. In order to study and illustrate genitalia, the specimens were fixed in 75% ethanol. Reproductive apparatus was extracted by means of scalpel, scissors and needles. Illustrations of genitalia were sketched using a camera lucida. All the specimens were studied and observed at the stereomicroscope (Leica MZ 7.5). Height and maximum diameter of the shell along with some parts of genitalia were measured (in millimeters) by a digital gauge. Voucher specimens were stored in collections indicated below. Toponyms (place-names) are reported following the "Geoportale Nazionale, Map IGM 1:25000, http://www.pcn.minambiente.it/viewer/. Each locality and/or collection site is named in the original language (Italian). Taxonomical references are based on the checklist of the fauna europaea (Bank, 2017) and other cited papers.

The materials used for this study are deposited in the following Museums and private collections: NMBE = Natural History Museum Bern, Switzerland; CL = Liberto Fabio collection, Italy, Cefalù; CS = Sparacio Ignazio collection, Italy, Palermo; CV = Viviano Roberto collection, Italy, Palermo.

ACRONYMS. AG = albumen gland; AAG = atrial accessory glands; BC = bursa copulatrix; DBC = duct of the bursa copulatrix; DP = distal penis; E = epiphallus; FO = free oviduct; G = penial papilla; GA = genital atrium; HD = hermaphrodite duct; O = ovotestis; OV = ovispermiduct; P = penis; PR = penial retractor muscle; S = stimulator; V = vagina; VD = vas deferens. ex/x = specimen/s.

RESULTS

Systematics

Classis GASTROPODA Cuvier, 1795
Infraclassis PULMONATA Cuvier in Blainville, 1814
Ordo STYLOMMATOPHORA A. Schmidt, 1855
Familia MILACIDAE Ellis, 1926
Genus *Milax* Ellis, 1926

Milax lopadusanus n. sp. (Figs. 1–11, 15–16)

TYPE LOCALITY. Lampedusa Island (Sicily, Italy) (Fig. 13).

TYPE MATERIAL. Holotype: Italy, Sicily, Lampedusa Island, Vallone dei Conigli, 35°30'55"N 12°33'20"E, 55 m, legit R. Viviano, 13.X.2017 (NMBE 553145). Paratypes: Italy, Sicily, Lampedusa Island, legit A. Corso, 17.X.2012, 1 ex (CL 13437); idem, Valle Imbriacole, 35°30'40"N 12°36'17"E, 18 m, legit A. Corso, XI.2012, 2 exx (CL 13407–13408); idem, surroundings of the town, legit T. La Mantia, 12.III.2015, 1 ex (CS); idem, near Vallone dei Conigli, legit G. Maraventano, 28.XII.2016, 4 exx (CS); idem, 1 ex (CL 17519); idem, Vallone Terranova, 35°30'50"N 12°34'18"E, 53 m, legit E. Schifani, 8.X.2017, 1 ex (CV); idem, Costa Tabaccara, Vallone, 35°30'47"N 12°33'46"E, 44 m, legit R.

Viviano, 9.X.2017, 1 ex (CV); idem, Dammuso, Casa Teresa, 35°31'27"N 12°32'23"E, 116 m, legit R. Viviano, 9.X.2017, 2 exx (CV); idem, Vallone dell'Acqua, 35°31'05"N 12°31'53"E, 83 m, legit R. Viviano, 11.X.2017, 1 ex (CV); idem, Valle Imbriacole, 35°30'56"N 12°35'45"E, 34 m, legit R. Viviano, 12.X.2017, 1 ex (CL 17520); idem, Vallone dei Conigli, 35°30'55"N 12°33'20"E, 55 m, legit R. Viviano, 13.X.2017, 2 exx (CL 17517–17518); idem, 1 ex (CV).

OTHER EXAMINED MATERIAL. *Milax nigricans.* Italy, Sicily, Lampedusa Island, legit A. Corso, XI.2012, 2 exx (CL 13404–13405); idem, legit G. Maraventano, III.2013, 3 exx, ex coll. I. Sparacio, (CL 13690–13692); idem, legit G. Maraventano, 18.XI.2014, 6 exx, ex coll. I. Sparacio (CL 17263–17268); idem, legit T. La Mantia, 28.X.2016, 2 exx, ex coll. I. Sparacio (CL 17428–17432); idem contrada Cozzo Monaco, T. La Mantia, 28.X.2016, 4 exx (CS); idem, Cala Galera, legit G. Maraventano and E. Prazzi, 26.XI.2016, 6 exx (CS).

Italy, Sicily, Palermo, Parco della Favorita, 11.XI.1995, 2 exx (CS); idem, Catania, Fontanarossa, 19.XII.1998, 2 exx (CS); idem, Sant'Agata di Militello, 21. XI. 1999, 2 ex (CS); idem, Palermo Ponte delle Grazie on the river Oreto, 28.XII.2002, 5 exx (CS); idem, Custonaci, southern slopes of Pizzo Monaco, 360 m, 38°02'44" N 12°48'11" E, 19.IV.2009, 3 exx (CL 4801–4803); Idem, Enna, M. del Barone, 37°30'58"N 14°13'58"E, 500 m, 07.II.2010, 1 ex (CL 6135); idem, Melilli, Sorg. Belluzza, 37°13'16"N 15°06'21"E, 104 m, 21.XI.2010, 4 exx (CL 8783–8786); idem, Caltanissetta, Ponte Capodarso, 37°29'43"N 14°08'41"E, 285 m, 08.XII.2012, 2 exx (CL 13073-13074); idem, Sambuca di Sicilia, C. Catena, 37°38'40"N 13°08'35"E, 280 m, 23.XII.2012, 1 ex (CL 13520); Tunisia, Utica, 37°03'17"N 10°03'44"E, 18 m, legit G. Sabatinelli, 25.I.2015, 4 exx (CL 220–223).

Milax gagates. France, Marsiglia, Plaine Maures, Le Canal des Maures, 43°20'N 5°21'E, 40 m, legit D. Pavon, 07.III.2009, 1 ex (CL); France, Salon-de-Provence, Boulevard des Alpilles, jardin au 222, 43°38'52"N 05°05'16"E, 85 m, legit D. Pavon, 12.IV.2010, 1 ex (CL); France, Marsiglia, Châteauneuf les Martigues, La Glaciere, 43°23'38"N 05°07'23"E, 33 m, legit, D. Pavon, 3.III.2013, 1 ex (CL).

Milax gasulli. Tunisia, Carthage, legit G. Sabatinelli, 30.XI.2015, 2 exx (CL 258–259); Tunisia, Boukornine, legit G. Sabatinelli, 30.XI.2015, 2 exx (CL 296–297).

DIAGNOSIS. Grey-brownish slug with genitalia characterized by elongated conical stimulator with a longitudinal crest along one side, spermatophore with conic anterior part, covered by bifurcated spines on one side and cylindrical posterior part covered by smaller and most dense spines on all sides.

DESCRIPTION OF HOLOTYPE. Slug medium-small sized, length 25.3 mm, maximum width: 6.3 mm after preservation. Narrow and pointed at its rear end, with distinct dorsal carina (kell) running from posterior apex of body to clypeus (mantel); shallow skin grooves; foot sole tripartite, with chevron pattern. When living the holotype had the yellow-greenish back and the brownish cypelio covered by numerous very small gray dots, yellowish dorsal carina, gray neck and head, grey-yellowish foot sole; after preservation the specimen is uniformly black on the upper part with yellowish keel and brown-greyish sides and sole. Clypeus shield-shaped, superficially granulated, with rhomboidal groove and a hollow near keel; pneumostome on right side of clypeus, postmedial; yellowish mucus.

Shell (limacella) nail-like, oval, well calcified, white in colour, with apex posterior and situated on major axis, at the highest point, rather flat dorsally and slightly convex ventrally (Fig. 5); length: 4 mm; diameter: 2.5 mm, height: 1 mm.

Genitalia (Figs. 8–10). General scheme of semidiaulic monotrematic type, consisting of ovotestis with many close acini; long hermaphrodite duct, entering base of small talon (Fig. 8); large albumen gland; well developed ovispermiduct; long free oviduct (5.5 mm), arising from vagina side by side with the very short duct of the bursa copulatrix (1.4 mm); large and roundish bursa copulatrix; short vagina (2 mm); a gelatinous substance envelops the distal part of the female genitalia. Vas deferens double length than penis + epiphallus, ending laterally at epiphallus tip; epiphallus cylindrical (2.5 mm) with a slight lateral swelling at its tip, a slight constriction separates the epiphallus from the penis; penis rather short (2 mm) and fusiform, divided by a faint constriction in a proximal part with

a short and flat penial papilla inside and a distal part with some longitudinal pleats on the inner wall (Fig. 9); penial retractor muscle ending laterally at the transition of the epiphallus to the penis; vagina and penis open into a wide genital atrium; mass of atrial accessory glands very large in relation to body size, communicating via multiple ducts with atrium. The stimulator contained inside genital atrial cavity, is conical, 3 mm long, with base oval in section, pointed apex, and an evident crest rises to half length of the stimulator, along one side.

Only a spermatophore was found in the examined specimens (Fig. 11), it is elongated, spiral, with conic anterior part, covered by spines on one side, the other side being smooth; four spines for each circular row; spine bifurcated with the two apexes multi-thorny; posterior part cylindrical, covered by smaller and most dense spines on all sides. The anterior part is broken, it was found in the duct of burs copulatrix and the anterior part coil in burs copulatrix. The reddish color of the spermatophora is due to the preservation of the specimens in denatured alcohol immediately after sampling.

VARIABILITY. Length of living adult specimens 45–55 mm, width 5–6 mm. The constriction separating the distal penis from the proximal penis may be more or less evident; apex of the stimulator more or less pointed.

ETYMOLOGY. The specific name refers to the Latin name of type locality: *lopadusanus*, that lives in Lampedusa.

BIOLOGY AND DISTRIBUTION. *Milax lopadusanus* n. sp. is until now known only from the type locality Lampedusa Island (Fig. 12), where it lives in sympatry with *M. nigricans*.

It occurs in natural habitats and it seems to prefer dark, damp sites with mediterranean maquis: *Thymbra capitata* (L.) Cav., *Pericloca laevigata angustifolia* (Labill.) Markgr., *Euphorbia dendroides* L., Graminaceae, etc. (Figs. 13–14). It may be found under stones, decaying plant material and similar debris, but it is very skilled at digging tunnels in the wet soil. Sexual activity occurs in autumn (November) and spring (March). We found juvenile or sub-adult specimens of *M. lopadusanus* n. sp. in October, adult specimens in November, only one adult was found in March. The examined specimens of *M. nigricans* of Lampedusa were juveniles in October and November and adults in December and March. *Milax nigricans* have larger populations that are closer to the inhabited center.

STATUS AND CONSERVATION. The restricted distribution makes *M. lopadusanus* n. sp. "Vulnerable", according to the Categories and Criteria of the IUCN Red List of Threatened Species (IUCN, 2017). Urbanisation and tourism development as well as agriculture could most probably be affecting the species diffusion and population richness.

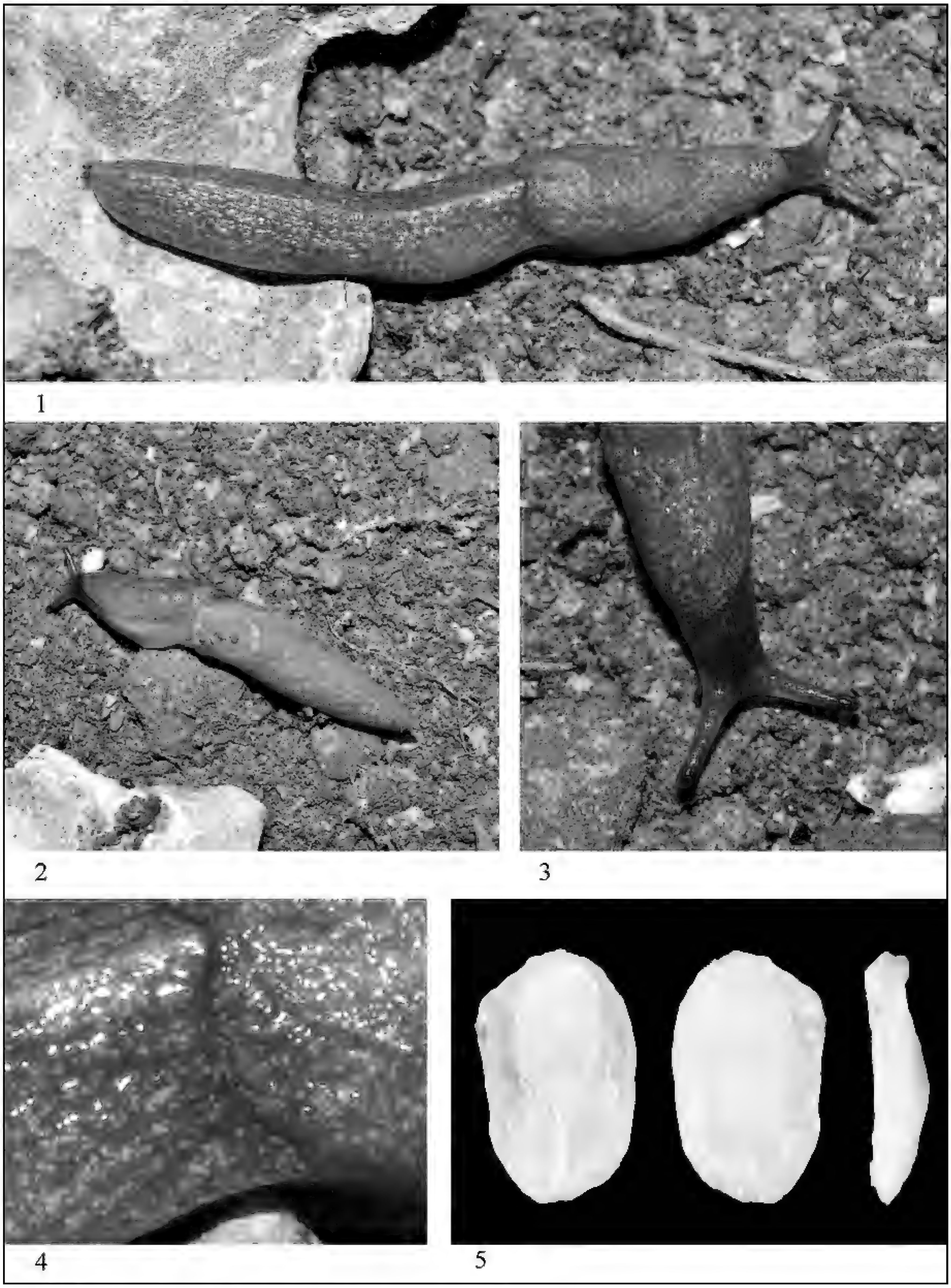
COMPARATIVE NOTES. To date, only two species of *Milax* are reported from Sicily: *M. nigricans* and *M. gagates* (Wiktor, 1987a; Manganelli et al., 1995; Bank, 2017), but many species of this genus were described in the past for several Sicilian localities.

Amalia insularis Lessona et Pollonera, 1882 (Lessona & Pollonera, 1882, type locality: Sassari in Sardinia and Palermo in Sicily), *A. doderleini* Lessona et Pollonera, 1882 (Lessona & Pollonera, 1882, type locality: Palermo in Sicily), *A. sicula* Lessona et Pollonera, 1882 (Lessona & Pollonera, 1882, type locality: Palermo in Sicily), *A. gagates benoiti* Lessona et Pollonera, 1882 (Lessona & Pollonera, 1882, type locality: Messina and Catania in Sicily), *A. mediterranea similis* Cockerell, 1891 (Cockerell, 1891, type locality: Catania in Sicily).

These taxa were described only on some external characters. Further, no type or syntypes are found in the Lessona and Pollonera's collections at the "Museo Regionale di Scienze Naturali di Torino", Italy (E. Gavetti *in verbis*), at the moment, or in the British Museum (Natural History) (see Altena Van Regteren, 1974).

Lessona & Pollonera (1882, Pl. II, figs 6-7) illustrate the genitalia of a specimen of *M. insularis* from Sardinia: the stimulator appears similar to that of *M. nigricans*. In addition Quick (1960: 150) examined some specimens of *Milax* sampled near Catania reporting "*to be the species with a papillate stimulator*".

We have examined numerous specimens of *Milax* sampled from many Sicilian localities and the islands surrounding Sicily (for a representative see examined material) and all these specimens show the typical characters of *M. nigricans*. For these reasons we agree with Giusti (1973), Wiktor



Figures 1–5. *Milax lopadusanus* n. sp. (Sicilian Channel, Italy). Fig 1: specimen in natural habitat. Fig. 2: colour of the foot. Fig. 3: colour of the head and the clypeus. Fig. 4: colour of the back and clypeus. Fig. 5: shell (holotype NMBE 553145).

Figures 6–10. Genitalia of *Milax lopadusanus* n. sp. from Lampedusa Island (Sicilian Channel, Italy) without the "gelatinous substance". Fig. 6: genitalia (CL 17517). Fig. 7: idem, with stimulator outside the genital atrium. Fig. 8: genitalia (holotype NMBE 553145). Fig. 9: idem, internal structure of atrium, penis, vagina and duct of the bursa copulatrix; Fig. 10: penial papilla of holotype (NMBE 553145). Fig. 11: spermatophore of *M. lopadusanus* n. sp. with enlargements of some isolated spines (CL 13406).

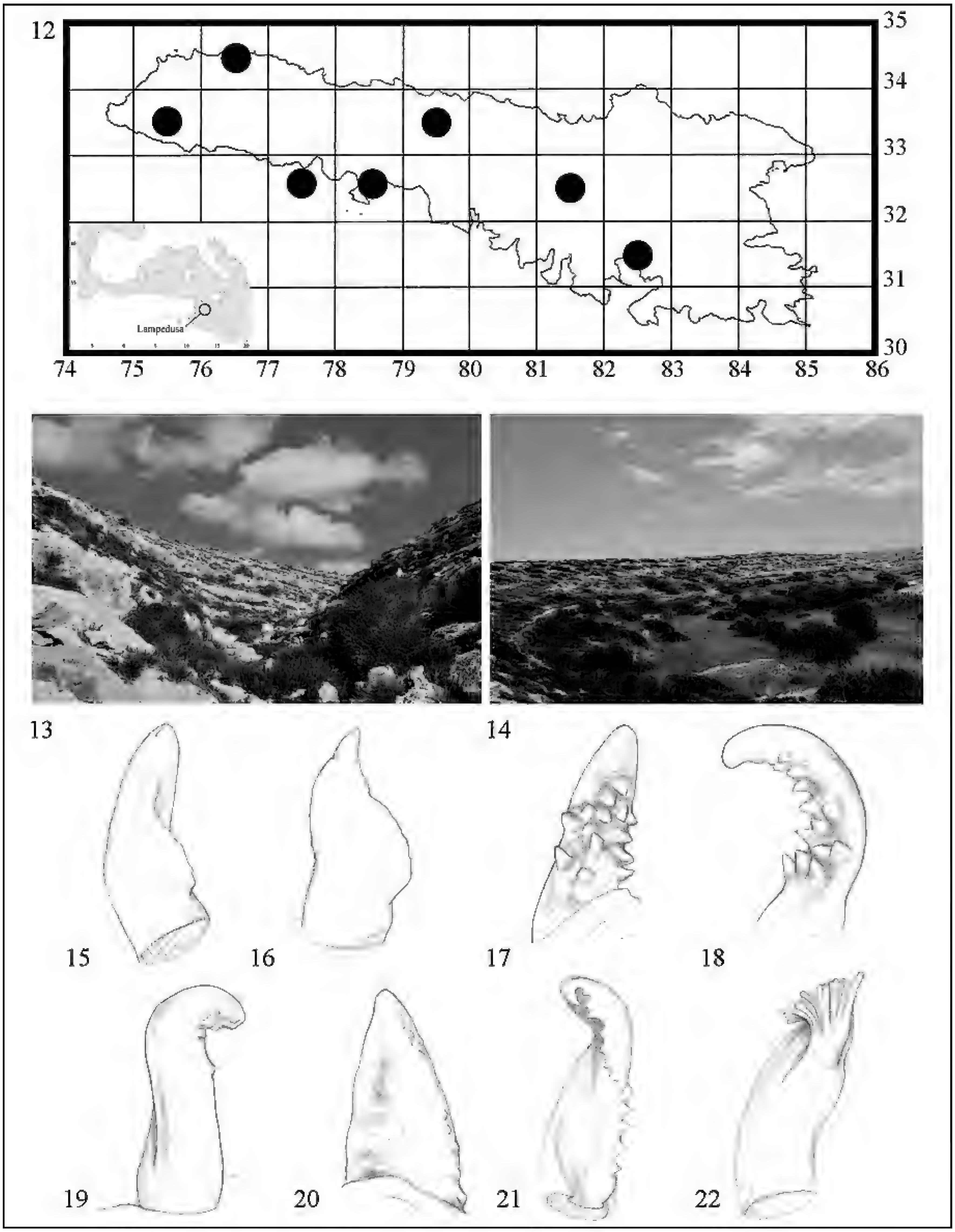


Figure 12. Distribution map of *Milax lopadusanus* n. sp. on a UTM map (1x1 square km) of Lampedusa. Figures 13–14. Landscape of Lampedusa Island. Fig. 13: Vallone dei Conigli. Fig. 14: Valle Imbriacole. Figures 15–22. Stimulators of *Milax* species. Fig. 15: *M. lopadusanus* n. sp., Lampedusa (CL 17517). Fig. 16: idem (CL 13407). Fig. 17: *M. nigricans*, Italy, Sicily, Custonaci (CL 4801). Fig. 18. *M. nigricans*, Italy, Sicily, Melilli (CL 8783). Fig. 19: *M. gagates* France, Salon-de-Provence (CL). Fig. 20: *M. gasulli* Tunisia, Boukornine (CL 297). Fig. 21: *M. gasulli* by Wiktor & Abbes (2008), modified. Fig. 22: *M. ater* by Wiktor & Abbes (2008), modified.

(1987a), Manganelli et al. (1995) and Bank (2017) in considering *A. benoiti*, *doderleini*, *insularis*, *sicula*, *similis*, all synonyms of *M. nigricans*.

Four species of *Milax* are currently considered valid from North-West Africa (Libya, Tunisia, Algeria, Morocco): *M. nigricans*, *M. gagates*, *M. gasulli* (endemic of North-East Tunisia) and *M. ater* (endemic of Northern Algeria) (Wiktor, 1987a; Nair et al., 1996; Borredà & Martínez-Ortí, 2017).

Nevertheless, other species names of Milacidae are reported in literature regarding the North Africa taxa: *Limax scaptobius* Bourguignat, 1861 (Bourguignat, 1861, type locality: Bougie and Constantine, Algeria), *Amalia cabiliana* Pollonera, 1891 (Pollonera, 1891, type locality: El-Hammam in Kabylie, Algeria), *A. gagates mediterrana* Cockerell, 1891 (Cockerell, 1891, type locality: Algeria) and *M. collingei* Hesse, 1926 (Hesse, 1926, substitute name of *A. maculata* Collinge, 1895, type locality: Algiers).

We did not have the opportunity to examine topotypic specimens, however Wiktor (1983, 1987a), based on examination of specimens from Algeria, puts *L. scaptobius* in synonymy with *M. gagates*, both *A. cabiliana* and *A. mediterranea* in synonymy with *M. nigricans* and *M. collingei* in synonymy with *T. sowerbyi*. In addition, Altena Van Regteren (1974) and Wiktor & Abbes (2008) did not find any type material of these taxa.

Milax lopadusanus n. sp. is well distinct from the sympatric *M. nigrican*s by the greyish-brown external colour, with yellowish kell (black or greyish colour with more raised kell in *M. nigricans*), by the smooth stimulator with a crest along one side (stimulator conical with several rows of spines or papillae in *M. nigricans*, Figs. 17–18) and by spermatophore with anterior part covered by spines only on one side, the largest spines are on the central part (in *M. nigricans* spermatophore covered by spines on all sides and along its whole length, with larger and strongly bifurcated spines on the anterior part (Wiktor, 1987a, b).

M. lopadusanus n. sp. is distinct from *M. gagates* for the greyish brown external colour, with yellowish dorsal carina (uniformly dark grey or blackish in *M. gagates*) for the conical stimulator with a crest (in *M. gagates* the stimulator is flattened, gradually narrowing towards its end, smooth or with several very small papillae on its tip, Fig. 19) and for the spermatophore with the posterior part cylindrical, covered by spines on all sides (in *M. gagates* the longer spermatophore is covererd by spines only on one side, the other side being smooth (Wiktor, 1987a, b).

Milax lopadusanus n. sp. is clearly distinguishable from *M. gasulli* by virtue of its greyish brown colour (black or grey with yellovish spots in *M. gasulli*), stimulator conical, with a crest (in *M. gasulli* stimulator is flated, with row of spines on a whole edge, Figs. 20–21). Spermatophore with anterior part covered by spines only on one side (covered on all sides by more strongly bifurcated spines in *M. gasulli*) (Wiktor & Abbes, 2008; Abbes et al., 2010)

Milax lopadusanus n. sp. is distinguishable from *M. ater* for its greyish brown colour (uniformly blackish in *M. ater*), penis shorter than epiphallus, (penis equal in length to epiphallus in *M. ater*), stimulator with an evident crest to half of its length and apex smooth (stimulator with smooth body and striped apex ornate by a sort of fan or small processes in *M. ater*, Fig. 22). The spermatophore in *M. ater* is unknown up to date (Collinge, 1895; Wiktor, 1987a).

REMARKS. *Milax lopadusanus* n. sp. seems similar to *M. gagates* for the spermatophora with bifurcated spines, that arise on the anterior part only on one side. Moreover it shares with *M. gasulli* the presence of a gelatinous substance that envelops the the distal part of the female genitalia. This gelatinous tissue is known only for *M. gasulli* and *M. lopadusanus* n. sp. (Altena van Regteren, 1974; Wiktor & Abbes, 2008).

The invertebrate fauna of Lampedusa includes many endemic species. They are mainly of African origin and they have differentiated for allopatric speciation. *Milax lopadusanus* n. sp. may have reached Lampedusa, possibly from North Africa, when emerged connections were estabilished during glaciations or earlier.

Milax lopadusanus n. sp. is added to the endemic terrestrial molluscs of Lampedusa that include four other endemic species: *Lampedusa lopadusae lopadusae* (Calcara, 1846), *Oxychilus* (*Oxychilus*) *diductus* (Westerlund, 1886), *Trochoidea cumiae* (Calcara, 1847) and *Cernuella metabola* (Westerlund, 1889) (Cianfanelli, 2002; Muscarella & Baragona, 2017).

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REFERENCES

Abbes I., Liberto F., Castillejo J. & Nouira S., 2010. A review of slugs and semi-slugs of Tunisia (Testacellidae, Milacidae and Limacidae). Journal of Conchology, 40: 219–232.

Altena Van Regteren C.O., 1974. Notes on land slugs, 23. A new species of *Milax* from Tunisia. Basteria, 38: 103–108.

Alzona C., 1961. Mollusca. In: Zavattari E. et al. (Eds.), Biogeografia delle Isole Pelagie. Fauna: Invertebrati. Rendiconti Accademia nazionale dei XL, Ser. IV, 11: 426–431.

Bank R.A., 2017. Fauna Europaea project. Checklist of the land and freshwater Gastropoda of Europe. http://www.nmbe.ch/sites/default/files/uploads/PDF_Upload/fauna_europaea_2017_03_16.pdf (Last access: 05.XI.2017).

Beckmann K.-H., 1992. Catalogue and Bibliography of the Land- and Freschwater Molluscs of the Maltese Islands, the Pelagic Islands and the isle of Pantelleria. Heldia, 2: 1–60.

Beckmann K.-H., 1998. Landmollusken der Mittelmeerinsel Djerba (Tunesien) (Gastropoda: Stylommatophora). Heldia, 2 (5/6): 161–164.

Borredà V. & Martínez-Ortí A., 2017. Contribution to the knowledge of the terrestrial slugs (Gastropoda, Pulmonata) of the Maghreb. Iberus, 35: 1–10.

Bourguignat M.J.R., 1861. Histoire des Limaces algériennes. Les Spicileges malacologiques, Vol. 1: 33–43, Pl. 15.

Burgio E. & Catalisano A., 1994. *Mus Lopadusae* (Muridae, Rodentia) nuova specie fossile dell'isola di Lampedusa (Agrigento, Sicilia). Il Quaternario, 7: 119–122.

Cianfanelli S., 2002. Molluschi non marini. In: Corti C., Lo Cascio P., Masseti M. & Pasta S., 2002. Storia Naturale delle Isole Pelagie. L'Epos, Palermo, 59–67.

Cockerell T.D.A., 1891. Notes on Slugs, chiefly in the Collection at the British Museum. Annals and Magazine of Natural History, 7: 328–341.

Collinge W.E., 1895. Notes on some slug from Algiers. Procedings of the malacological society of London, 1: 336, Pl. 23.

Giusti F., 1973. Notulae Malacologicae, XVIII. I molluschi terrestri e salmastri delle isole Eolie. Lavori della Società Italiana di Biogeografia (Nuova Serie), 3: 113–306, 39 Figg., 1 tab., 16 tavv.

Grasso M. & Pedley M.H., 1985. The Pelagian Islands: a new geological interpretation from sedimentological and tectonic studies and its bearing on the evolution of the central Mediterranean Sea (Pelagian block). Geologica Romana, 24: 13–34.

Hesse P., 1926. Die Nacktschnecken der palaearktischen Region. Abhandlungen des Archivs für Molluskenkunde, 2: 1–152.

IUCN, 2017. The IUCN Red List of Threatened Species. Version 2017-3. http://www.iucnredlist.org (Last access: 05.XI.2017).

Lessona M. & Pollonera C., 1882. Monografia dei limacidi italiani. Loescher, Torino, 82 pp.

Manganelli G., Bodon M., Favilli L. & Giusti F., 1995. Gastropoda Pulmonata. In: Minelli A., Ruffo S. La Posta S. (Eds.), Checklist delle specie della fauna italiana, 16. Calderini, Bologna, 60 pp.

Muscarella C. & Baragona A., 2017. The endemic fauna of the Sicilian islands. Biodiversity Journal, 8: 249–278.

Nair G.A., El-Toumi F.F., Eltayeb K.M., Bosnaina A.M. & Bhyan K.C., 1996. Habitat, occurrence and density of some pulmonate slugs of north-east Lybia (Mollusca, Milacidae and Limacidae). African Journal of Zoology, 110: 251–26.

Pollonera C., 1891. Appunti di malacologia VIII - Sui Limacidi dell'Algeria. Bollettino dei Musei di Zoologia ed Anatomia comparata della Regia Università di Torino, VI (100): 1–5.

Quick H.E., 1960. British slugs (Pulmonata; Testacellidae, Arionidae, Limacidae). Bulletin of the British Museum (Natural History) Zoology, 6: 103–226.

Wiktor A., 1983. Some data on slugs of Morocco and Algeria with description of a new *Deroceras* species (Gastropoda, Pulmonata). Malakologische Abhandlungen, 8: 155–166.

Wiktor A., 1987a. Milacidae (Gastropoda, Pulmonata) - systematic monograph. Annales Zoologici, 41: 154–319.

Wiktor A., 1987b. Spermatophores in Milacidae and their Significance for Classification (Gastropoda, Pulmonata). Malakologische Abhandlungen, 12: 85–100.

Wiktor W. & Abbes I., 2008. A tunisian slug *Milax gasulli* Altena, 1974 and its morphology (Mollusca: Gastropoda: Milacidae). Folia Malacologica, 16: 69–73.

Biodiversity Journal, 2017, 8 (4): 937–942

A new remarkable species of the *Alvania scabra* (Philippi, 1844) group from the Ionian Sea: *A. scuderii* n. sp. (Gastropoda Rissoidae)

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ABSTRACT A new species of *Alvania* Risso, 1826 (Gastropoda Rissoidae) is described, based on 80 living specimens and shells found in Eastern Sicily, Ionian Sea, between Messina and Catania. This new species belongs to the *A. scabra* (Philippi, 1844) group. The description, pictures, and drawing of the soft parts are presented in this paper. There are also comparisons with other Mediterranean and Atlantic similar species briefly reported towards the end.

KEY WORDS Gastropoda; Rissoidae; *Alvania*; new species; Sicilian coast; Recent; Taxonomy.

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INTRODUCTION

The Ionian Sea has been the subject of countless studies since the earliest attempts of science to describe its great variety of organisms. Even in recent times, numerous papers have reported studies which vouch for the great biodiversity of this part of Sicily in particular. In fact, a lot of new species have been described (e.g. see the last contributions in chronological order: Bogi & Campani, 2006; 2007; Reitano & Buzzurro, 2006; Cecalupo & Robba, 2010; Scuderi, 2014), and many are still considered endemic.

Rissoidae is one of the most diverse family of marine molluscs in the world and many authors have added new taxa and information on the taxonomy of this family of gastropods.

Further in this paper there is the description of another new, cryptic species of the genus *Alvania* Risso, 1826 (Gastropoda Rissoidae), related to a peculiar sciaphilous environment of the Eastern Sicilian coasts. This new species belong to the so-called *A. scabra* (Philippi, 1844) group, which in the past has been treated as taxonomically problematic. Aradas & Benoit (1872–76), in fact, dedicated more than a single page of their book to "*Rissoa*" *scabra* of Philippi (1844), concluding that at least two species are involved under this name (Aradas & Benoit, 1872–76, p. 202: "…*la Riss. scabra di Philippi e la scabra Auctorum sono due specie distintissime*"). So, according to Aradas & Benoit (1874: p. 202) the *A. scabra* sensu Auctorum is different from *A. scabra* of Philippi and they named it "*Rissoa schwartzii*". Therefore, *A. schwartzii* (Aradas & Benoit, 1874) is the repleacement name of *A. scabra* sensu Auctorum and synonym of *A. lanciae* Calcara, 1845, while *A. mutabilis* Weinkauff, 1868 is synonym of *A. scabra* of Philippi (Priolo, 1953: p. 72). *A. schwartzii* (Aradas & Benoit, 1874) is not at all present in any checklist consulted (see for instance WoRMS, 2017). The examination of the external soft parts of the specimens of this group of *Alvania* led to more accurate studies, which were concluded, on one hand, with results reported by Villari

& Scuderi (2017) on some taxa morphologically closely related to *A. scabra*, and, on the other hand, to what here is described as a new species.

MATERIAL AND METHODS

Numerous living specimens and shells were found on algae of hard substrates, mainly in schiaphilous side of stones during July and August 2016. Collecting methods consist on brushing stones during ARA and apnea immersions, as reported in Villari & Scuderi (2017). Living specimens were stored in aquarium to observe the soft parts. Drawing of these latter were made by pencil and colored pastels.

ACRONYMS. Museo Zoologico dell'Università di Bologna, Bologna, Italy (MZB); Alberto Villari malacological collection, Messina, Italy (AVC); Museo della Fauna del Dipartimento di Veterinaria dell'Università di Messina, Messina, Italy (MFV-ME); Danilo Scuderi malacological collection, Catania, Italy (DSC); Pasquale Micali, Fano, Italy (PMC).

RESULTS

Systematics

Phylum MOLLUSCA Cuvier, 1797
Classis GASTROPODA Cuvier, 1795
Subclassis CAENOGASTROPODA Cox, 1960
Ordo LITTORINIMORPHA Golikov et Starobogatov, 1975
Superfamilia RISSOOIDEA Gray, 1847
Familia TROCHIDAE Rafinesque, 1815
Genus *Alvania* Risso, 1826

Alvania scuderii n. sp.

EXAMINED MATERIAL. Holotype, Messina, Ganzirri, Sicily, Italy, rocky bottom, 2/4 meters, MZB (collection number: MZB47004) (Fig. 1). Paratype 1, same data of the holotype, in MFV-ME collection (collection number: 935/05-12-2017) (Fig. 2). Paratype 2 (Figs. 3, 4), same data of the holotype, in DSC. Other paratypes, same data of the holotype, 9 living specimens and 14 shells, all in AVC, DSC and PMC collections.

DESCRIPTION OF HOLOTYPE. Shell (Fig. 1) ovate-conic, slender, fragile, not perforated, 1.3 mm high and 0.65 mm broad. Teleoconch consist of 3.3 whorls, with marked sutures. Sculpture is constituted by equally spaced spiral chords and axial ribs, which at the intersection form minute, rounded rows of tubercles. In the first tele-whorl, only two spiral chords could be detected, bearing few (6, 7) not marked tubercles each. At the suture of the second whorl, a third faint adapical spiral chord appear and remains as the minor of all till the end of the last whorl, while a fourth starts between the two older whorls only at the end of the second tele-whorl. In the last whorl, four spiral chords are present: the two in central position are stronger, bearing 11, 12 little and well-rounded tubercles. The upper one is less marked and bears smaller tubercles, while the lower one is almost faint, with only low and rough tubercles. A faint spiral micro-sculpture is present over all the surface of the whorls and in particular over the spiral chords, that are more dense. From the upper insertion of the external lip to the base, four more smooth spirals are present, the last two being almost vanishing. The axial ribs are only slightly thicker than the spirals, barely opisthocline, 6–8 in number on the early tele-whorls, 10 on the body whorl, becoming almost absent just at the fourth spiral. The last whorl forms rather 66% of the total shell height. Aperture ovate, drop shaped, withsharp, simply and not denticled peristome. Color almost entirely amber, included the protoconch. Axial ribs are almost of the same color of the rest of the shell, while spirals are dark brown, making the shell a lyrate appearance.

Protoconch (Figs. 5–9) slender, cylindrical, paucispiral, constituted by 2 regularly convex whorls. Nucleus inflated, slightly inrolled. Sculpture of very thin spiral threads, alternated with granulated areas at the beginning. Granules in the remainder of the protoconch are arranged in only one row comprised between two very subtle threads each (Fig. 6); few granules could be coalescent. The living animal (Figs. 17–19) is almost entirely white, with gray to pale blackish strips on the opercular area. Yellow strips and stains are present scattered on the snout, in the head before the eyes, along the cephalic tentacles, the foot, making a "smile" figure inside the operculum. Four metapodial tentacle are visible. Operculum (Fig. 1) thin, paucispiral, with eccentric nucleus.

VARIABILITY. The collected specimens seem almost all of the same dimensions and color, and only few of them slightly paler. The sculpture of the shell could be more or less marked. Some completely dark shells of *A. scabra* were collected in particular environment - e.g. inside rocky caves - but they differ in protoconch outline, sculpture and dimensions, uniform color - not darker - of the spirals on the shell surface and the soft parts color pattern.

ETYMOLOGY. The specific name is after my friend Danilo Scuderi (Catania, Italy), Italian Marine Biologist.

BIOLOGY AND DISTRIBUTION. Along the rocky and very shallow waters, between algae on stones. The species in known only from type locality.

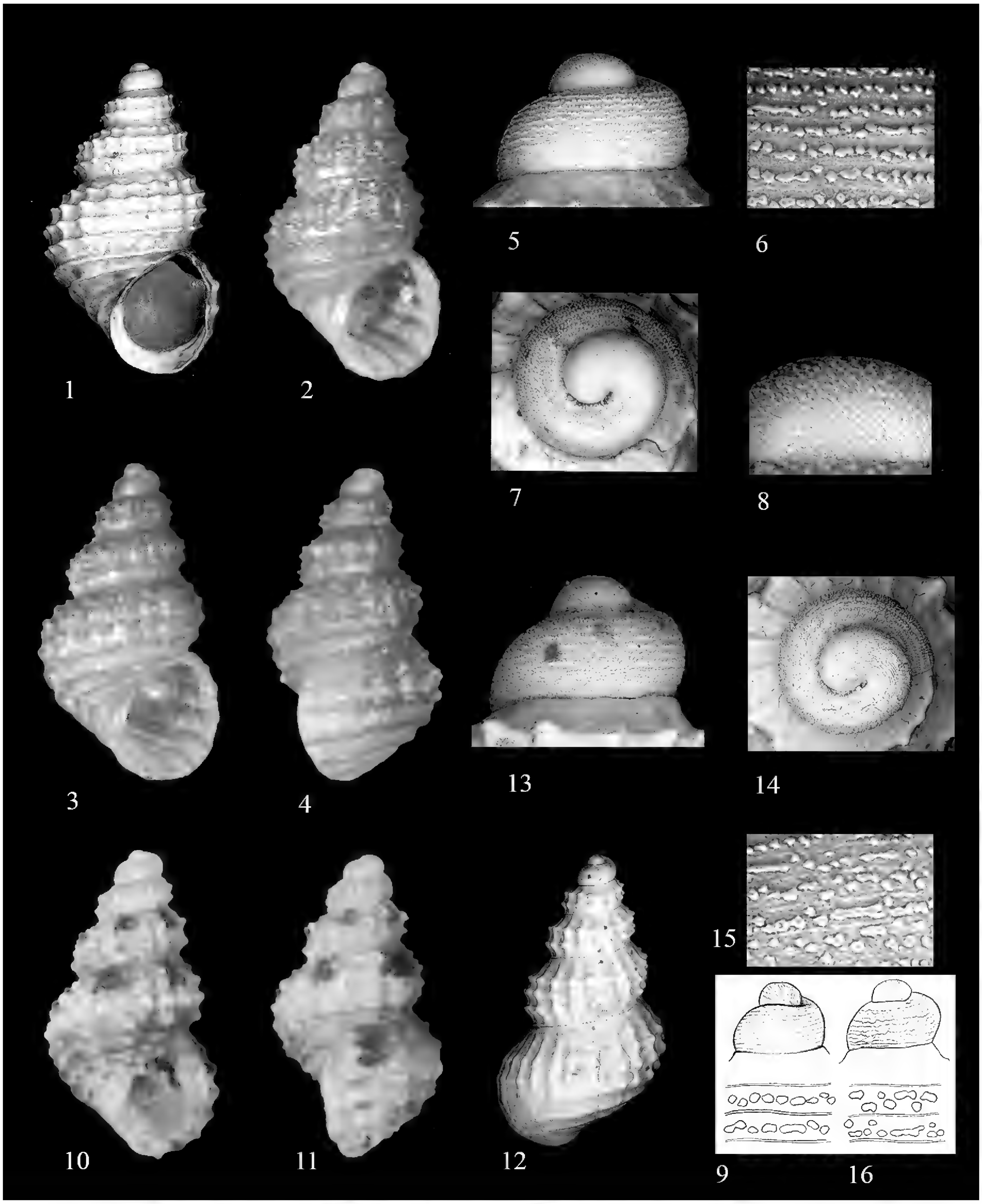
COMPARATIVE NOTES. Among Mediterranean species, *A. scuderii* n. sp. is morphologically similar to *A. scabra* (Figs. 10–12), but differs in both proto- and teleoconch shell characters and different chromatic patterns of the soft parts. The uniform amber shell cut through by darker spirals is the most visible morphological character which distinguishes the new species from not only the most common bright form of *A. scabra* but even from the darker form, which occurs in some sciaphilous environments. In addition, *A. scabra* has a different protoconch, for shape, nucleus dimensions and sculpture, which in the new species appears regularly spirally sculptured (Figs. 5, 7, 9). Each spiral cord is constituted by granules, sometimes coalescent, arranged in only one row between two spiral treads (Fig. 6) instead of two (Fig. 15), as in *A. scabra*, which appears irregularly sculptured (Figs. 13–16). Moreover the chromatic pattern of the soft parts are different, being almost whitish in the new species (Figs. 17–19) and white and black in *A. scabra* (Fig. 20).

Other Mediterranean species of the *A. scabra* group are discussed in Villari & Scuderi (2017). Of these species *A. sororcula* Granata-Grillo, 1877 has soft parts (Fig. 21) with different chromatic pattern, intermediate between those of *A. scabra* and *A. scuderii* n. sp., a higher and heavier shell, with different proportion of whorls, broader base and protoconch. The color of the shell and the sculpture make it immediately separable from the new species, particularly for the wider subsutural zone, lacking the adapical spiral chord. For the same reason, the new species is distinguishable from *A. sculptilis* (Monterosato, 1877), even if this latter is really a good species (see for instance Villari & Scuderi (2017).

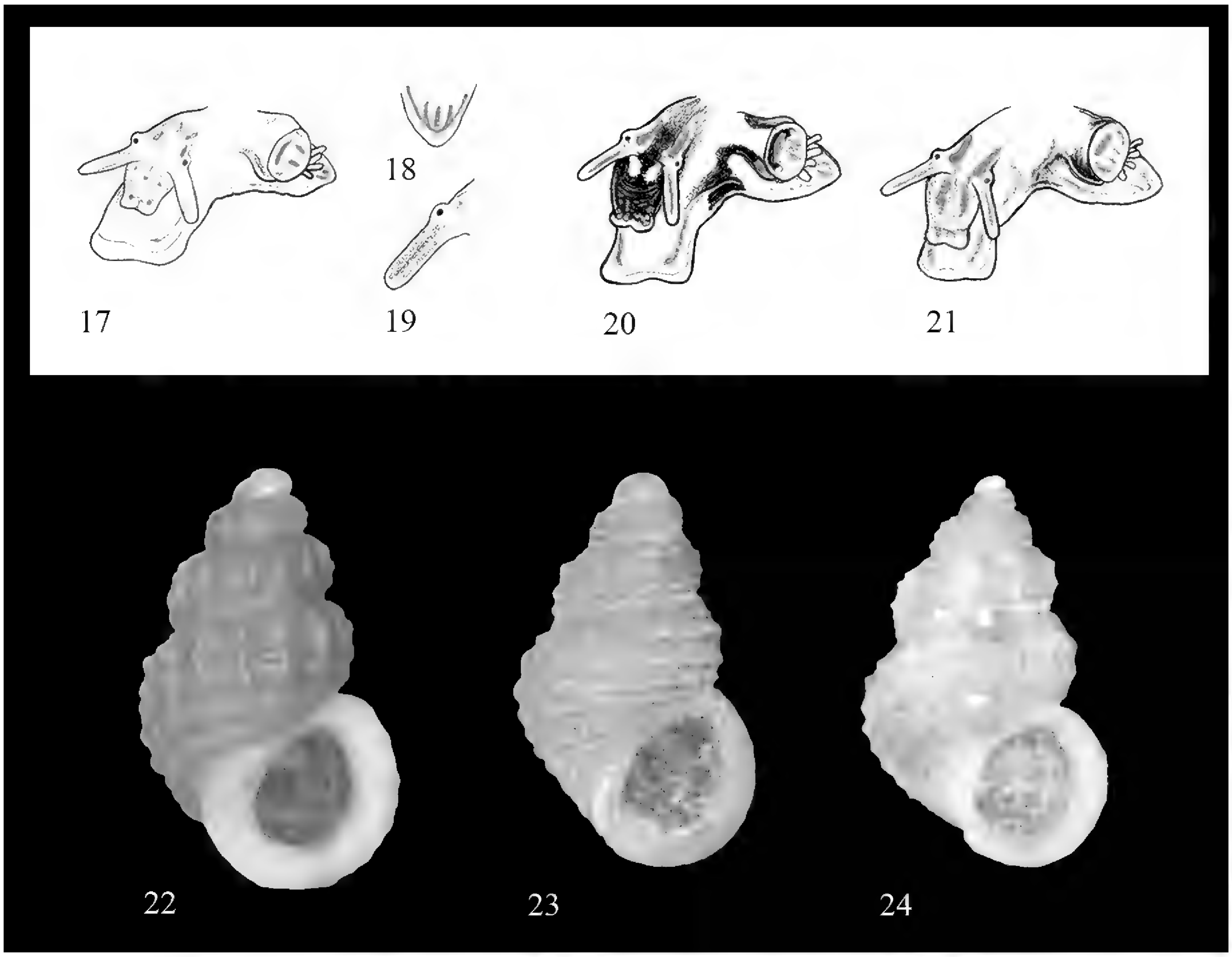
However, the new species share with *A. lucinae* Oberling, 1970 and *A. oranica* (Pallary, 1900), if these latters are really two different species, the presence of the fourth spiral chord in the whorls preceding the last, but these two species are separable on account of the same differences above reported for *A. scabra*.

We have to add a few more words concerning similar Atlantic species, just to complete the comparisons overview. Among Eastern Atlantic species, morphological resemblances could be detected in some species, which have, regardless, a different protoconch sculpture. *Alvania mediolittoralis* Gofas, 1989 has a similar color, but differs for the less slender shape and bigger dimensions, a different protoconch and the lacking of darker spirals. *Alvania angioyi* van Aartsen, 1982 has a similar protoconch shape, but different sculpture, and the shell ornamentation and color are not the same. For the same reasons, *A. tarsodes* (Watson, 1886), easily recognizable for the pointed apex with dark nucleus, is considered different. The minute shell with different shell colour and sculpture differentiates the new species from *A. grancanariensis* Segers, 1999, which is more similar to the species of *A. lanciae* (Calcara, 1845) group. The resemblance with *A. macandrewi* (Manzoni, 1868) (Fig. 22) and *A. watsoni* (Schwartz in Watson, 1873), whose shell has often an entirely dark shell, is only superficial, because the former has a heavier shape and coarse sculpture, with a dark and coarse protoconch (Fig. 20), while the latter bears only spirals over almost the entire teleoconch (Fig. 23). Among Western Atlantic species, *A. auberiana* (d'Orbigny, 1842) and *A. faberi* De Jong et Coomans, 1988 could be considered similar to the *A. scabra* group, even if they show the presence of a wide and smooth subsutural zone. Protoconchs are differently sculptured. The former has a bigger and almost entirely whitish shell, a smaller mouth and whorls with a general outline very characteristic, with the two last whorls proportionally bigger than the previous (Fig. 24). The latter has more similar dimensions and better proportionate whorls, but it is stouter and has only two tele-whorls of different color.

Seguenza L. (1903), among fossil rissoids, cited *A. scabra* without adding any other reference to its morphs or varieties, and reported and figured two species which could be morphologically related to



Figures 1–9. *Alvania scuderii* n.sp., all from Messina (Italy). Fig. 1: SEM photograph of the holotype, 2.1 mm. Fig. 2: paratype 1, same data, 2.1 mm. Figs. 3, 4: paratype 2, same data, 2.0 mm. Figs. 5–8: SEM photograph of the protoconch of the holotype; Fig. 6: detail of sculpture. Fig. 7: protoconch seen from upward. Fig. 8: detail of sculpture of the nucleus. Fig. 9: drawing of the protoconch and details of micro-sculpture. Figures 10–16. *Alvania scabra* from Messina (Italy). Figs. 10, 11: shell, 2.0 mm. Fig. 12: SEM photograph of a shell, same data, 2.2 mm. Figs. 13–16: SEM photograph of the protoconch. Figs. 13, 14: protoconch seen from aside and from upward. Fig. 15: detail of sculpture. Fig. 16: drawing of the protoconch and details of micro-sculpture.



Figures 17– 19. *Alvania scuderii* n.sp. from Messina (Italy). Fig. 17: drawing of external soft parts. Fig. 18: detail of the posterior end of the foot. Fig. 19: detail of a cephalic tentacle. Fig. 20: *A. scabra*, drawing of external soft parts. Fig. 21. *A. sororcula*, Messina, drawing of external soft parts. Fig. 22. *A. macandrewi*, Ponta Sào Lourenço, Madeira, shell, 2.6 mm. Fig. 23. *A. watsoni*, Ponta Sào Lourenço, Madeira, shell, 1.7 mm. Fig. 24. *A. auberiana*, Porto S. Antonio, Jamaica, shell, 1.9 mm.

the new species, but which are clearly different. The first is *Acinulus dubius* Seguenza G., 1873, which therefore is more related to *Alvania cimicoides* (Forbes, 1844), while the second is *Actonia granulosculpta* Seguenza, 1903, described as new species, which share the general shape with the new species, but which is easily distinguishable for the first two smooth tele-whorls.

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REFERENCES

Aradas A. & Benoit L., 1872–1876. Conchigliologia vivente marina della Sicilia. Atti dell'Accademia Gioenia di Scienze Naturali, (3) 6: 1–113 + pl. 1–2 [1872]; 113–226 + pl. 3–4 [1874]; 227–324 + pl. 5 [1876].

Bogi C. & Campani E., 2006. *Jujubinus curinii* n. sp.: una nuova specie di Trochidae per le coste della Sicilia. Bollettino Malacologico 41 (9–12): 99–10.

Bogi C. & Campani E., 2007. *Tricolia landinii*, una nuova specie per le coste orientali della Sicilia. Iberus, 25: 27–31.

Cecalupo A. & Robba E., 2010. The identity of *Murex tubercularis* Montagu, 1803 and description of one new genus and two new species of the Cerithiopsidae (Gastropoda: Triphoroidea). Bollettino Malacologico, 46: 45–64.

Philippi R.A., 1844. Enumeratio molluscorum Siciliae

cum viventium tum in tellure tertiaria fossilium, quae in itinere suo observavit. Volumen secundum continens addenda et emendanda, nec non comparationem faunae recentis Siciliae cum faunis aliarum terrarum et com fauna periodi tertiariae. Eduard Anton, Halle [Halis Saxorum]. iv+303: 13–28.

Priolo O., 1953. Nuova revisione delle conchiglie marine di Sicilia. Atti della Accademia Gioenia di Scienze Naturali di Catania, 9: 53–91.

Reitano A. & Buzzurro G., 2006. Descrizione di una nuova specie di Cerithiopsidae per le coste della Sicilia orientale (Mollusca Triphoroidea). Il Naturalista siciliano, 30: 549–554.

Seguenza L., 1903. Rissoidi neogenici della provincia di Messina. Paleontographica Italica, 9: 35–60, pl. 11.

Scuderi D., 2014. A new species of rissoid of the genus *Alvania* Risso, 1826 from the E-Sicily: *Alvania maximilicutiani* n. sp. (Gastropoda Rissoidae). Biodiversity Journal, 5: 201–208.

Villari A. & Scuderi D., 2017. Taxonomical on some poorly known mollusca species from the Strait of Messina (Italy). Biodiversity Journal, 8: 193–204.

WoRMS - World Register of Marine Species, 2017. http://www.marinespecies.org/aphia.php?p=taxdetails&id=138439 (genus *Alvania* page), last date of consultation: 26.11.2017.

Biodiversity Journal, 2017, 8 (4): 943–946

First record of fossil *Jujubinus curinii* Bogi et Campani, 2006 (Gastropoda Trochidae) in north-eastern Sicily (Italy)

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ABSTRACT The discovery of a fossil specimen of *Jujubinus curinii* Bogi et Campani, 2006 (Gastropoda Trochidae) is reported from the geologic stage of "Milazziano" (Tyrrhenian, Pleistocene) located at Capo Milazzo, North-Eastern Sicily. The specimen has been found during a study on the *Jujubinus* Monterosato, 1884 material stored in the Monterosato's collection at the Museo Civico di Zoologia of Rome, Italy.

KEY WORDS Gastropoda; Trochidae; *Jujubinus curinii*; fossil; Sicily; Italy.

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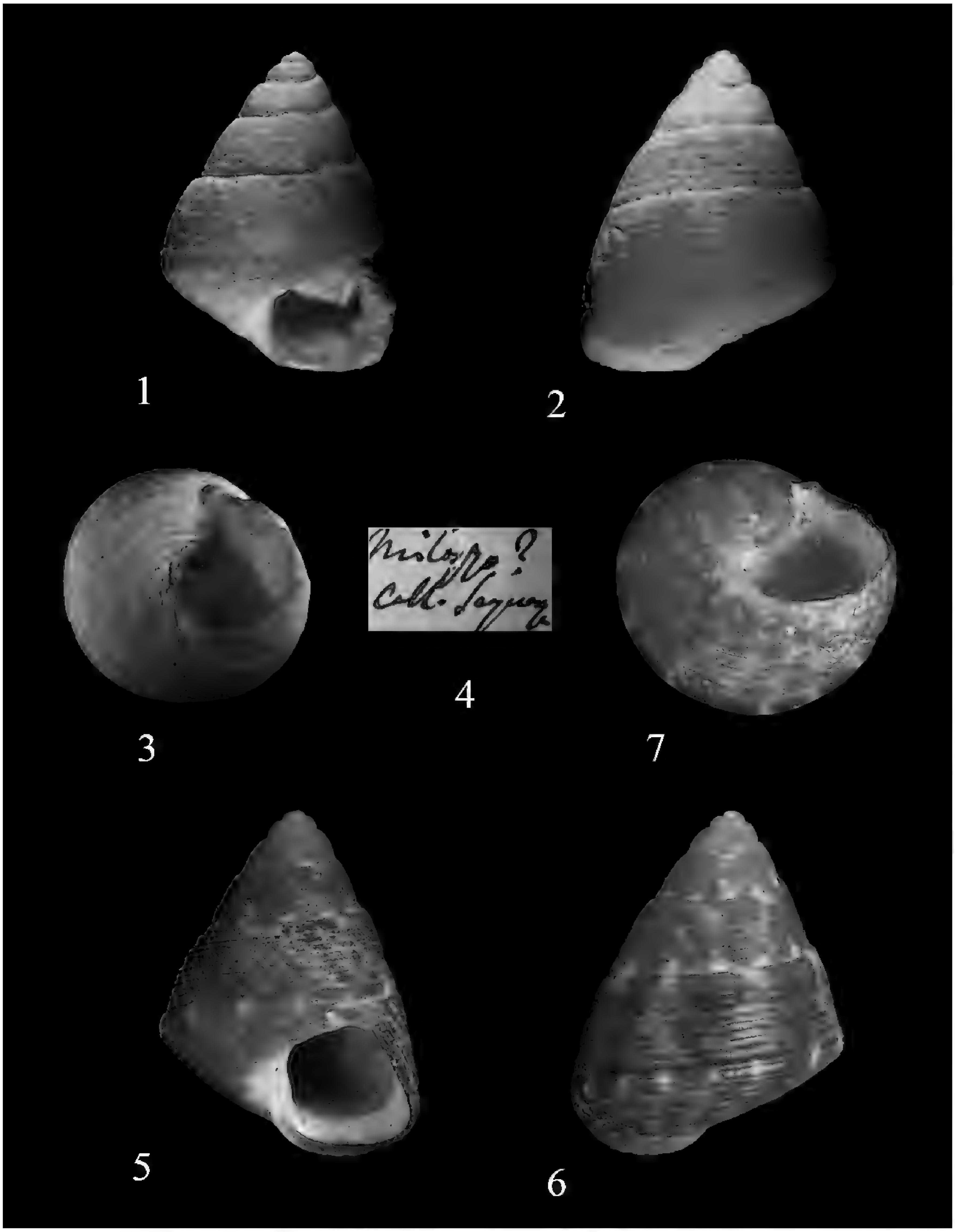
INTRODUCTION

Nowadays, the genus *Jujubinus* Monterosato, 1884 (Gastropoda Trochidae) is represented in the eastern European Ocean and the Mediterranean Sea by 18 species according to CLEMAM (Gofas & Le Renard, 2017). Most of them live in the intertidal zone down to about 80 meters, and are constantly associated with photophilic algal vegetation and/or marine phanerogams (Mariottini et al., 2013).

The *Jujubinus* shell usually displays a slender trochiform shape, with a marked sculpture consisting of 4 to 8 spiral threads variable in size, often beaded, an evident basal cord, and with tiny prosocline lamellae within thread interspaces (Monterosato, 1884). The taxon *Jujubinus curinii* Bogi et Campani, 2006 has a peculiar shell morphology, consisting in a completely smooth sculpture lacking the typical interspaced prosocline lamellae and with a reduced basal cord (Bogi & Campani, 2006). These characters have been observed on other recently described species of the *J. curinii* complex, which have increased the number of the so-called "smooth" *Jujubinus* (Smriglio et al., 2014; Smriglio et al., 2015). Nowadays, this group of species sharing those two diagnostic features is composed of four members: *J. curinii*; *J. eleonorae* Smriglio, Di Giulio et Mariottini, 2014; *J. trilloi* Smriglio, Di Giulio et Mariottini, 2014; and *J. alboranensis* Smriglio, Mariottini et Oliverio, 2015. With the present short note, we report for the first time a fossil specimen of this taxon, which we have found during a study on the *Jujubinus* material stored in the Monterosato collection at the Museo Civico di Zoologia of Rome (Italy).

MATERIAL AND METHODS

During an investigation on the *Jujubinus* ma-



Figures 1–4. *Jujubinus curinii* Bogi et Campani, 2006. Fossil specimen, H: 5.3 mm, D: 4.4 mm. Plan "Milazziano" of Capo Milazzo. Frontal, dorsal and basal views (Figs. 1–3). Monterosato's original label, Monterosato collection (MCZR-11670) (Fig. 4). Figures 5–7. *Jujubinus curinii*. Recent specimen, H: 4.2 mm, D: 2.8 mm. Scilla, Reggio Calabria, Italy, 42 m depth. Frontal, dorsal and basal views. CS-PM collection.

terial present in the Monterosato's collection at the Museo Civico di Zoologia di Roma (MCZR), we could separate a specimen of *J. curinii* from a lot of five *J. exasperatus* (Pennant, 1777) (drawer E/12; MCZR-11670).

ABBREVIATIONS. CS-PM = private collection Carlo Smriglio-Paolo Mariottini, Rome, Italy; D = diameter; H = height; MCZR = Museo Civico di Zoologia di Roma, Rome, Italy.

RESULTS

Systematics

Phylum MOLLUSCA Cuvier, 1797
Classis GASTROPODA Cuvier, 1795
Subclassis VETIGASTROPODA Salvini-Plawen, 1980
Superfamilia TROCHOIDEA Rafinesque, 1815
Familia TROCHIDAE Rafinesque, 1815
Genus *Jujubinus* Monterosato, 1884

Jujubinus curinii Bogi et Campani, 2006
(Figs. 1–4, 5–7).

The *J. curinii* species complex comprises four "smooth" members: *J. alboranensis*, *J. curinii*, *J. eleonorae*, and *J. trilloi* Smriglio (Bogi & Campani, 2006; Smriglio et al., 2014; Smriglio et al., 2015). Unfortunately, no molecular analyses are available to shed light on the phylogenetic relationship of this group with the other members of the genus *Jujubinus* s.s. We had the chance to come across a very well conserved and still coloured fossil specimen, stored in the Monterosato's collection at the MCZR, which was easily identified as *J. curinii* (Figs. 1–4, 5–7) and separated from a lot of five *J. exasperatus*. The Monterosato's handwritten label indicates that the material was sent to him by Giuseppe Seguenza, from a questionable locality (Milazzo with a question mark). In spite of that, the collecting locality can be fairly trustworthy, since it refers to the well characterized Pleistocene Milazziano section of the Milazzo Peninsula (Messina Province, Sicily) deposits (Ruggieri & Greco, 1965; Ruggieri, 1967; Micali & Villari, 1991), and investigated in the past by Seguenza (1903, 1908). We would like to recall that the Pleistocene Milazziano is a controversial geological period between the Sicilian and Tyrrhenian Termination I (upper Pleistocene/Holocene boundary dated at 11,500 yr BP according to Cita et al., 2005) chronostratigraphic stages, typically represented in marine facies by the Milazzo's fossil bench, and with temperate fauna composed almost exclusively of molluscs and corals (Ruggieri & Greco, 1965; Cita et al., 2005). This report for the first time assigns a temporal placement of *J. curinii*, dating back in a range from 130,000 to 11,500 yr BP (Cita et al., 2005).

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We thank Pasquale Micali (Fano, Italy) for providing literature concerning Seguenza's papers.

REFERENCES

Bogi C. & Campani E., 2006. *Jujubinus curinii* n. sp. una nuova specie di Trochidae per le coste della Sicilia. Bollettino Malacologico, 41: 99–101.

Cita M.B., Capotondi L. & Asioli A., 2005. The Tyrrhenian stage in the Mediterranean definition, usage and recognition in the deep-sea record. A proposal. Accademia Nazionale dei Lincei Rendiconti Classe Scienze Fisiche Matematiche e Naturali, S. 9, 16: 297–310.

Gofas S. & Le Renard J., 2017. CLEMAM: Check List of European Marine Mollusca. Available at http://www.somali.asso.fr/clemam/index.clemam.html. Accessed 2017-oct-01.

Mariottini P., Di Giulio A., Appolloni M. & Smriglio C., 2013. Phenotypic diversity, taxonomic remarks and updated distribution of the Mediterranean *Jujubinus baudoni* (Monterosato, 1891) (Gastropoda Trochidae). Biodiversity Journal, 4: 343–354.

Micali P. & Villari A., 1991. Le specie malacologiche di Salice (Messina) Istituite da Giuseppe Seguenza. Atti dell'Accademia Peloritana dei Pericolanti Classe di Scienze Fisiche, Matematiche e Naturali, 67 (Supplemento) 1: 345–363.

Monterosato T. Di Maria, 1884. Conchiglie littorali mediterranee. Il Naturalista siciliano, 3: 102–111.

Ruggieri G., 1967. Lo strato tipo del piano Milazziano. Accademia gioenia di scienze naturali in Catania, 6: 311–318.

Ruggieri G. & Greco A., 1965. Studi geologici e paleontologici su Capo Milazzo con particolare riguardo al Milazziano. Geologica Romana, 4: 41–88.

Seguenza G., 1903. Rissoidi neogenici della provincia di Messina. Palaeontographia Italica, 9: 35–60.

Seguenza G., 1908. Il Miocene della provincia di Messina. Atti della Reale Accademia dei Lincei, 5: 379–385.
Smriglio C., Di Giulio A. & Mariottini P., 2014. Description of two new *Jujubinus* specie (Gastropoda: Trochidae) from the Sicily Channel, with notes on the *Jujubinus curinii* complex. Zootaxa, 3815: 583–590.
Smriglio C., Mariottini P. & Oliverio M., 2015. A new species of the *Jujubinus curinii* species complex: *J. alboranensis* spec. nov. (Gastropoda: Trochidae) from the Alboran Sea. Iberus, 33: 151–157.

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New record of Dwarf Sperm Whale *Kogia sima* (Owen, 1866) from the Mediterranean Sea (Cetacea Kogiidae)

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ABSTRACT

We report a new record of the Dwarf Sperm Whale *Kogia sima* (Owen, 1866) (Cetacea Kogiidae) in the Mediterranean Sea, following the stranding of a dead female of this species occurred on 4th February 2017. The specimen was found at the Trentova seaside near Agropoli (Salerno Province, Southern Italy) within the area of the Cilento, Vallo di Diano and Alburni National Park. The molecular analysis of a partial sequence of the mitochondrial 16S rRNA confirmed the species identification based on anatomical and morphological characters. This stranding is the third on the Mediterranean and Italian coasts.

KEY WORDS *Kogia sima*; Kogiidae; Cetacea; stranding; Mediterranean Sea; mtDNA.

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INTRODUCTION

The Dwarf Sperm Whale *Kogia sima* (Owen, 1866) (Order Cetacea, Suborder Odontoceti, Family Kogiidae), commonly known as “Cogia di Owen” in Italian, has been recognized as a distinct species from *K. breviceps* (Blainville, 1838) (Chivers et al., 2005).

Kogia sima is distributed worldwide, in warm-temperate and tropical oceanic waters of both hemispheres. This species lives over the continental shelf and slope as well as in offshore waters and occasionally strands in cold-temperate areas and in warmer coasts. *Kogia sima* range covers the western Atlantic from southeastern U.S.A. to Brazil, including the Antilles; the eastern Atlantic from Portugal to Cape Province; the Indian Ocean from Cape Province to India and South Australia; the western Pacific from Japan to New Zealand; the eastern Pacific from southern Canada to Chile. It is also found in the Sea of Japan and in the Persian Gulf (Taylor et al., 2012). The most reliable records on the distribution and biology of the species are based on stranded individuals or occasionally on those retrieved from small fisheries (Caldwell & Caldwell, 1989). The seasonality and migration patterns of this species are unknown.

This species is protected by CITES (listed in Appendix II) and it is under the Marine Mammal Protection Act (NOAA) of 1972. At European level

the species is considered "in need of strict protection" in the European Union by the Annex IV of the Council Directive 92/43/EEC of May 21st 1992 on the conservation of natural habitats and of wild fauna and flora, known as "Habitats Directive". *Kogia sima* is also protected by the "Barcelona Convention" for the Protection of the Marine Environment and the Mediterranean Coast (and its new Application Protocol relative to Special Protection Zones and the Biological Diversity in the Mediterranean (Specially Protected Areas of Mediterranean Importance (SPAMI) adopted on 1995), and it is considered an "Endangered or threatened species" in the Annex II. The species is also included in the Appendix II of the "Bern Convention" relative to the Conservation of European Wildlife and Natural Habitats, considered as "Strictly protected fauna species". It is covered by the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) according to Annex I. Furthermore, the species is classified as "Data Deficient" on the IUCN Red List of Threatened Species (vers. 2017-3) (Taylor et al., 2012) and further researches are needed in order to better understand the impact of threats of different nature on this species. Finally, in the Mediterranean Sea, the Dwarf Sperm Whale is considered a "Vagrant" species (Notarbartolo di Sciara & Birkun, 2010; Cagnolaro et al., 2015).

In this note we report a new record of the Dwarf Sperm Whale, *K. sima*, in the Mediterranean Sea.

MATERIAL AND METHODS

In order to ascertain the correct species determination of the study samples, we conducted a molecular study on the specimen beached near Agropoli and on the specimen stranded nearby Agrigento in 2002. Total genomic DNA was extracted according to the method described by Sokolov (2000) from alcohol preserved tissue samples. A mitochondrial 16S rRNA gene fragment was amplified with PCR using the universal primer pairs 16Sa and 16Sb (Palumbi, 1996) and sequenced with automated sequencer ABI 3110 (Applied Biosystems). Chromatograms were edited with Chromas Lite©, aligned with BioEdit 7.0.5.3 (Hall, 1999) and blasted in GenBank.

RESULTS AND CONCLUSIONS

On 4th February 2017 a dead female specimen, phenotypically ascribable to *K. sima*, was found beached lifeless on the seaside of Trentova Bay near Agropoli (Salerno Province, Campania, Southern Italy), within the territory of the Cilento, Vallo di Diano and Alburni National Park (CVDANP) (Lat. 40°20'56"N - Long. 014°58'29"E) (Figs. 1–3). The individual was 195 cm long (head-to-tail length) and weighed 115.5 kg. The carcass was at medium stage of decomposition (Code 3, moderately decomposed) according to Geraci & Loundsbury (2005). This stranding is the third on the Mediterranean and Italian coasts and the first documented record of *Kogia* G.R. Gray, 1846 for the Campania Region (Maio & Quercia, 2006; Maio et al., 2012) Fig. 4).

Dwarf Sperm Whales are extremely rare for the entire Mediterranean basin and there are only two other reports of beached specimens of this species, namely: a specimen found dead and partly buried on 20th May 1988 at Foce Chiarone along the border between Tuscany and Lazio Region (Centro Studi Cetacei, 1990) and an individual that stranded alive and then died in 2002 in the Province of Agrigento (Centro Studi Cetacei, 1990). The former animal had a total body length of 220 cm, and although it was not possible to sex this specimen, the complete closure of the vertebral epiphyses and the almost complete (90%) closure of the pulp cavity of teeth indicated that it was probably an adult (Baccetti et al., 1991). The latter individual stranded alive at Eraclea Minoa, nearby Agrigento, Western Sicily, on 8th September 2002. This specimen measured 207 cm in total length and must therefore be considered an adult or a subadult (Bortolotto et al., 2003). These two specimens from the Mediterranean Sea are preserved in Italian museums (Cagnolaro et al., 2014; Insacco et al., 2014).

The resulting 16S rRNA sequences were of 470 bp, and showed 100% identity (uncorrected p-distance) between the two studied samples (Agropoli and Eraclea Minoa). A BLAST search retrieved 98% identity with homologous 16S rRNA segments of three deposited sequences in GenBank of *K. sima*. One of them was from an Indian sample, which in turn showed an identity of 100% and 99.8%, respectively, with the remaining two samples from unknown localities (Accession

numbers: MG000942, AF334490, AF304066). Considering these preliminary molecular evidences, our two studied samples can be assigned to *K. sima* and they would represent the sister group of the other three available samples. Furthermore, the dorsal fin was located at about the midpoint of the body length, it had a relatively long base and measured 19.8 cm in height, therefore representing over 10% of total body length (i.e.: > 5% of TBL which identified *K. sima* and not *K. breviceps*).

All these data support the fact that this specimen is a *K. sima* and not a *K. breviceps*, according to morphological characters of the species reported in literature (Jefferson et al., 1993).

According to Caldwell and Caldwell (1989), Robineau (2005) and Perrin et al. (2009) the total body length of adults ranges from 210 to 270 cm and the weight from 135 to 272 kg with females generally slightly smaller than males. Dwarf Sperm Whales become sexually mature at 2.5–5 years, when they reach a length of about 2 meters. The estimated lifespan for this species may be up to 22 years. Therefore, we can consider the specimen an adult.

The skeleton (without the skull, which was unfortunately lost) was collected and it will be exposed in "CVDANP in "Villa Matarazzo" Museum Centre, at S. Maria of Castellabate (Salerno).

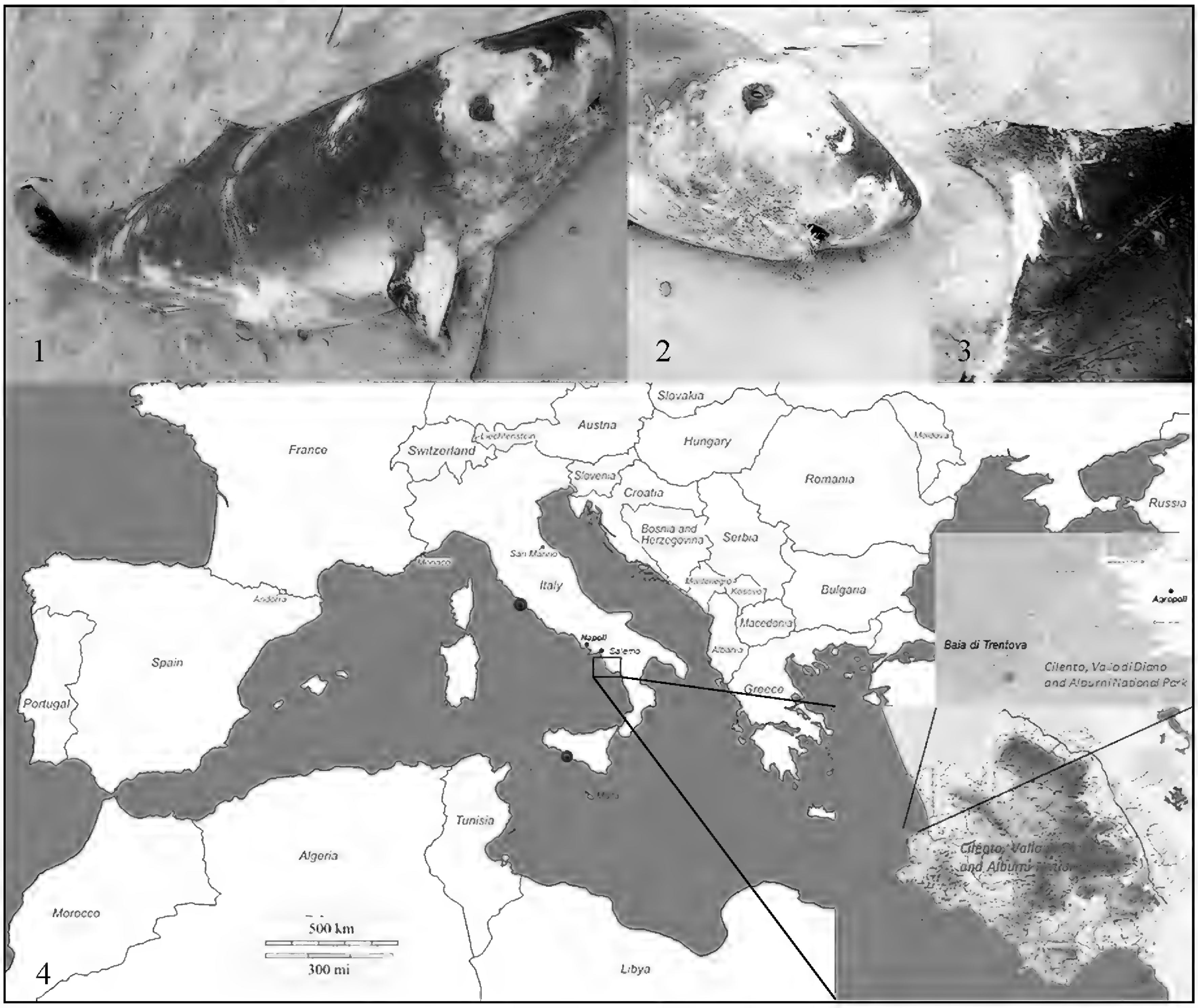

Figure 1. The female specimen of Dwarf Sperm Whale, *Kogia sima*, found beached lifeless on the seaside of Trentova Bay near Agropoli (Salerno, Campania) within the territory of the "Cilento, Vallo di Diano and Alburni National Park" on 4th February 2017. Figure 2: particular of the head. Figure 3: particular of the dorsal fin (photos by A. Gasparro). Figure 4. • Known data records of specimens stranded in the Mediterranean Sea. ◦ This report.

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REFERENCES

Baccetti N., Cancelli, F. & Renieri, T., 1991. First record of *Kogia simus* (Cetacea, Physeteridae) from the Mediterranean Sea. Mammalia, 55: 152–154.

Bortolotto A., Papini L., Insacco G., Gili C., Tumino G., Mazzariol S., Pavan G. & Cozzi B., 2003. First record of a dwarf sperm whale, *Kogia sima* (Owen, 1866) stranded alive along the coasts of Italy. 31st Symposium of the European Association for Aquatic Mammals. Tenerife, Spain, 14–17 march 2003, 1–8 pp.

Cagnolaro L., Cozzi B., Notarbartolo di Sciara G. & Podestà M. (Eds.), 2015. Fauna d'Italia Vol. XLIX. Mammalia IV. Cetacea. Calderini, Bologna, 375 pp.

Cagnolaro L., Maio N. & Vomero V. (Eds.), 2014. The cetacean collections of Italian museums. First part (living Cetaceans). Museologia Scientifica Memorie, 12: 1–420.

Caldwell D.K. & Caldwell M.C., 1989. Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838); Dwarf sperm whale *Kogia simus* Owen, 1866. In: Handbook of Marine Mammals (Ridgway S.H., Harrison S.R., eds), Vol. 4: River Dolphins and the Larger Toothed Whales. Academic Press, London, pp. 235–260.

Centro Studi Cetacei, 1990. Cetacei spiaggiati lungo le coste italiane. III. Rendiconto 1988. Atti della Società italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano, 130 (1989): 269–287.

Centro Studi Cetacei, 2004. Cetacei spiaggiati lungo le coste italiane. XVII. Rendiconto 2002. Atti della Società italiana di scienze naturali e del Museo civico di storia naturale di Milano, 145: 155–169.

Chivers S.J., Leduc R.G., Robertson K.M., Barros N.B. & Dizon A.E., 2005. Genetic variation of *Kogia* spp. with preliminary evidences for two species of *Kogia sima*. Marine Mammal Science, 21: 619–634.

Geraci J.R. & Loundsbury V.J. 2005. Marine mammals ashore: a field guide for strandings. 2nd ed. National Aquarium in Baltimore, Baltimore, MD, pp. 167–228.

Hall T.A., 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucleic Acids Symp 1999, 41: 95–98.

Insacco G., Buscaino G., Buffa G., Cavallaro M., Crisafi E., Grasso R., Lombardo F., Lo Paro G., Parrinello N., Sarà M. & Spadola F., 2014. Il patrimonio delle raccolte cetologiche museali della Sicilia. Museologia Scientifica Memorie, 12: 391–405.

Jefferson T.A., Leatherwood S. & Webber M.A., 1993. FAO species identification guide. Marine Mammals of the World. F.A.O., Roma.

Maio N., Pollaro F., Di Nocera F., De Carlo E. & Galiero G., 2012. Cetacei spiaggiati lungo le coste della Campania dal 2006 al 2011 (Mammalia: Cetacea). Atti della Società italiana di scienze naturali e del Museo civico di storia naturale di Milano, 153: 241–255.

Maio N. & Quercia F., 2006. Cetacei spiaggiati lungo il litorale campano: ricerca e conservazione. In: Gugliemi R. & Nappi A. (Eds.), Atti Convegno: "La Natura in Campania: aspetti biotici e abiotici". Napoli, 18 novembre 2004: 158–164.

Notarbartolo di Sciara G. & Birkun A. Jr., 2010. Conserving whales, dolphins and porpoises in the Mediterranean and Black Seas: an ACCOBAMS status report, 2010. ACCOBAMS, Monaco.

Palumbi S.R., 1996. Nucleic acids II: the polymerase chain reaction. In: Hillis D.M., Moritz C. & Mable B.K. (Eds.), Molecular Systematics, 2nd Edition. Sunderland, USA, 205–247.

Perrin W.F., Würsig B. & Thewissen J.G.M. (Eds.), 2009. Encyclopedia of Marine Mammals (Second Edition). Academic Press - Elsevier, San Diego, CA. xxix, 1316 pp.

Robineau D., 2005. Cétacés de France. Faune de France vol. 89. Fédération Française des Sociétés de Sciences Naturelles, Paris, 646 pp.

Sokolov E.P., 2000. An improved method for DNA isolation from mucopolysaccharide-rich molluscan tissue. Journal of Molluscan Studies, 66: 573–575.

Taylor B.L., Baird R., Barlow J., Dawson S.M., Ford J.K.B., Mead J.G., Notarbartolo di Sciara G., Wade P. & Pitman R.L., 2012. *Kogia sima*. The IUCN Red List of Threatened Species, Version 2012: e. T11048A17695273.http://dx.doi.org/10.2305/ IUCN. UK.2012.RLTS.T11048A17695273.en. Downloaded on 14 December 2017.

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The allochthonous crayfish *Procambarus clarkii* (Girard, 1852) (Crustacea Cambaridae) from the subterranean stream of the Ausi cave (Latium, Italy): the second documented case of cave invasion

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ABSTRACT In this paper, data on the second case in Europe of hypogean environment invasion by the crayfish *Procambarus clarkii* (Girard, 1852) (Crustacea Cambaridae) are reported. Sixteen specimens were collected and measured during spring and late summer 2017 and other numerous specimens were observed from the entrance until 500 meters inside the cave. The presence of at least two shelter tunnels dug on the clayey stream bank suggests a stable colonization of the cave. Many individuals collected were characterized by bluish chaele indicating sexual activity. The omnivorous diet of this crayfish, its resistance to adverse environmental conditions, its high reproduction rate and dispersal capability allow us to predict that this species could have a strong and negative impact on the aquatic and terrestrial cave communities.

KEY WORDS Cambaridae; *Procambarus*; groundwater; colonisation; cave habitat.

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INTRODUCTION

Cave habitats are characterized by unique biological communities of remarkable diversity. Hypogean environments are still scarcely known, but the studies on this fields are numerous and ongoing in many parts of the world. In particular, groundwater biodiversity has attracted the attention of many researchers in recent years, mainly for two aspects: the peculiarity of its fauna, whose composition is different compared to the surface freshwater fauna, and its high level of endemisms (Deharveng et al., 2009; Gibert & Culver, 2009). The species characterizing these particular habitats are vulnerable to local extinctions caused by human impacts, such as groundwater pollution, water extraction and habitat deterioration (Danielopol et al., 2003). Furthermore, in the last decades the increase in allochthonous species invasions in Europe represents a new risk for the delicate equilibrium of the cave ecosystem. In fact, the presence of alien species strongly affects the endemic ones, causing the reduction in their population size and, in some case, local extinctions. The effects of the alien species on endogenous species are particularly magnified in the fragile cave environments, even if only few data on

cave invasion by alien species are available in literature, e.g. Asiatic clam *Corbicula fulminea* (Müller, 1774) in France (Callot-Girardi et al., 2012), the New Zealand mudsnail *Potamopyrgus antipodarum* (Gray, 1843), the American spider *Psilochorus simoni* (Berland, 1911) and the Japanese diplopod *Oxidus gracilis* (Koch, 1847) in Italy (Zapparoli, 2008; Bodon et al., 2009; Sparacio et al., 2017).

One of the most successful and best known invasive species of aquatic ecosystems in Europe is the North American red swamp crayfish *P. clarkii* (Girard, 1852), nowadays widely distributed in the world due to its biological features, such as plastic life cycle, high fecundity, ability to rapidly disperse in the habitat, and tolerance to a wide range of environmental conditions (Gherardi, 2006). In Europe, this successful invader, was first introduced in Spain in the 1970s and then in the north of Italy in the 1980s, and now it has colonized most of the surface freshwater systems from the north to the central Italy (Aquiloni et al., 2010). The first occurrence of crayfish *P. clarkii* in hypogean water bodies in Europe (Portugal and Italy) is reported by Mazza et al. (2014).

In this paper, we report the second case of a recent invasion of a subterranean environment in Italy by *P. clarkii* (Fig. 1). The possible implications of the cave colonization is briefly discussed. Although presently there are no evidences of direct impact on the local subterranean aquatic environment, the massive occurrence of this crayfish in the cave is presented and discussed in relation to its potential role in the deterioration of the subterranean aquatic and terrestrial community.

MATERIAL AND METHODS

Our study has been carried out in the Ausi cave (cadaster number 342La, 41°30'33" N 13°16'27"E) since summer 2016, as a part of a more extensive faunistic investigation of the the Ausoni Mountains caves. The cave, located at 55 meters above sea level in Fornaro hill locality near Prossedi (Latina, Latium, Central Italy) has been declared Site of Community Importance (code n. IT6040001) under the European Commission Habitats Directive (92/43/EEC) since 2016, for the occurrence of seven bat species which use this cave as a site of reproduction and hibernation (Bollettino Ufficiale della Regione Lazio, 2016).

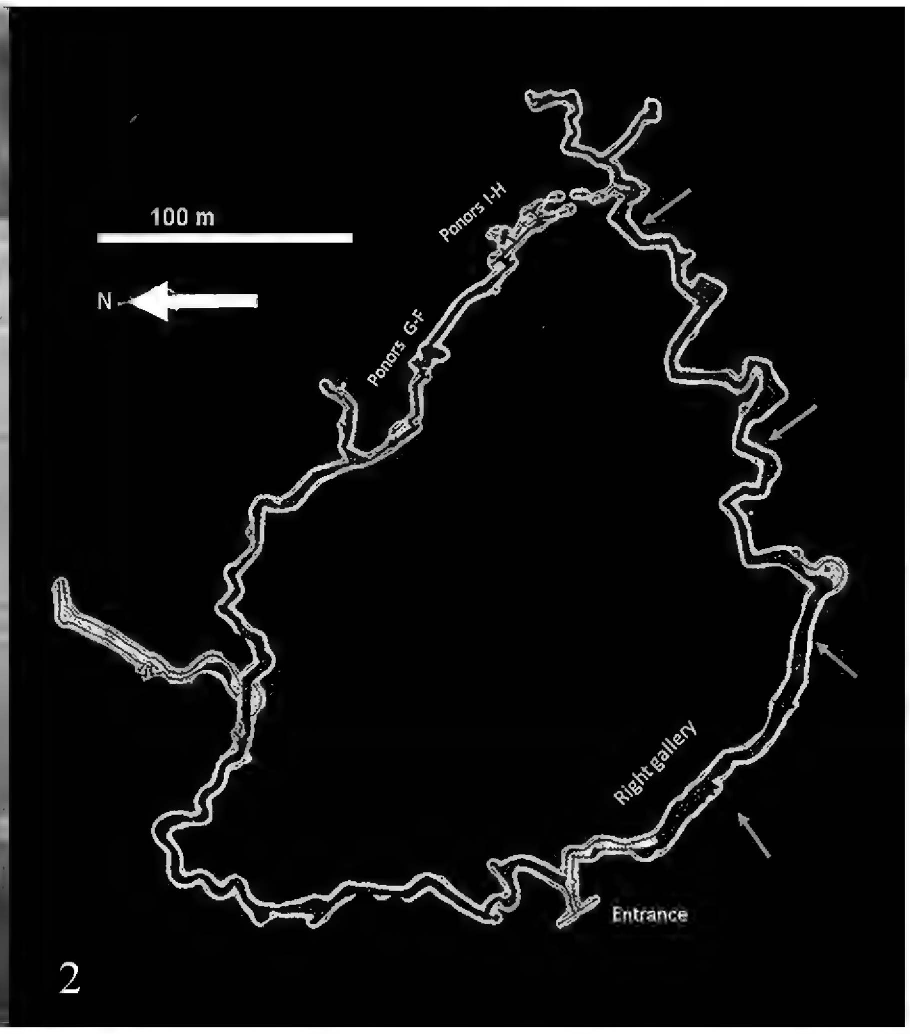

Figure 1. Adult specimen of *Procambarus clarkii* in the Ausi cave (Latium, Italy).
Figure 2. Map of the Ausi cave (Latium, Italy). Yellow arrows indicate the sites of crayfishes samplings.

The cave is 1,505 meters long and it is composed by two galleries of about equal length, starting few meters from the big entrance and functioning as a resurgence connected with the near Amaseno river. The right gallery, 530 meters long, is crossed by a perennial stream characterized by a variable flow depending on the season. In summer, the water flow is often very low and in the first 300 meters of the cave the stream is reduced to a series of pools of different deepness. The left gallery, which is approximately 510 meters, shows only a sporadic water flow while it is permanently occupied by ponds deep even a meter along its entire length. The stream goes into the cave at the points I, H and G-F, as shown in the cave map (Fig. 2). These points correspond to the upper entrances of the subterranean system, draining most of the surface water of the plateaux above the cave that extends until Villa Santo Stefano village (Mecchia et al., 2003).

Specimens of *P. clarkii* were actively captured using a fishery net only in the right gallery of the cave. Each specimen was measured according to three morphological parameters: TL=total length, CL=carapax length and ChL= chaele length, using a digital calliper (accuracy 0.1 mm) and weighed with a portable digital balance (accuracy 0.1 g). Water temperature was recorded using a digital thermometre (accuracy 0.1 °C). For the identification of the species was used Mazzoni et al. (2004), the sex of mature individuals was determined by the occurrence of modified pleiopods in males and of the annulus ventralis in females. The species composition of the aquatic zoocenose was evaluated using Latella (1995) and data from our three recent samplings (16 July 2016, 10 November 2016 and 03 June 2017). A survey on the Amaseno river and on the little streams connected with the superior entrance was conducted on 1st November 2017 in order to verify the occurrence of *P. clarkii* in the epigean habitat surrounding the cave.

RESULTS

In the first two sampling dates no specimens of *P. clarkii* were observed and only from April 2017 numerous individuals of the crayfish started to be found in the cave. In Table 1, sampling dates, occurrence of *P. clarkii* and water temperature are re-

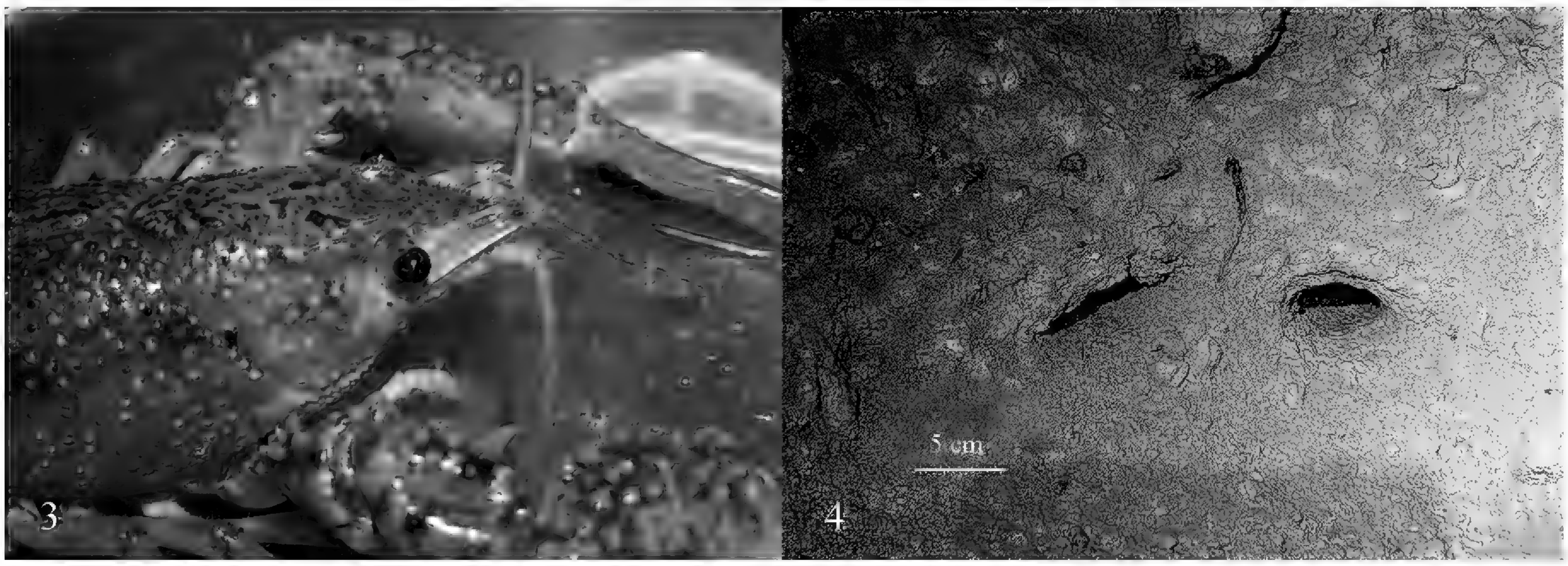

Figure 3. *Procambarus clarkii* showing the bluish color of the chaele indicating sexual activity.
Figure 4. *Procambarus clarkii* shelter tunnels in the Ausi cave (Latium, Italy).

Date	Specimens observed	Specimens collected	T °C
8.IV.2017	15	--------	/
14.IV.2017	20	5 (2M,1F and 2 juveniles)	13.4
17.IX.2017	30	11 (6M and 5F)	15

Table 1. Specimens observed and collected and temperature recorded in each sampling date.

ported. The survey conducted in the epigean habitats confirmed the occurrence of this allochthonous crayfish both in the Amaseno river and in the little streams draining water on the calcareous plateaux above the cave.

The crayfish were observed along all the right underground stream, about 30 meters from the entrance up to 500 meters inside the cave, mainly in the deep pools formed by the river (Fig. 2).

In total, 16 individuals were collected, five on 14th April 2017 and eleven on 17th September 2017. In males, TL ranged between 8.4 and 11.2 cm, CL between 6 and 4.5 cm, ChL between 6 and 2.7 cm and the weight between 17 and 44 g. In females, TL ranged between 9.3 and 11.4, CL between 4.8 and 5.8 cm, ChL between 1.9 and 4.0 cm and the weight between 30 and 40 g.

All the captured specimens, both adults and immatures were almost pigmented. Some males individuals captured on 17th September 2017 showed the typical bluish chelae colouration that indicates sexual activity, as reported in De Luise (2010) (Fig. 3). In the same sampling date, two shelter tunnels were observed on the bank of the underground stream about 300 meters inside the cave. The tunnels were dug in the clayey river bank, few centimeters above the water level (Fig. 4). For an evaluation of the possible impact on subterranean ecosystem, the aquatic biocenose composition is reported. On the whole, at least 21 taxa were identified (Table 2). Arthropods are the main group represented in the water bodies with the Crustaceans Amphipods *Niphargus longicaudatus* (A. Costa, 1851) and *Gammarus elvirae* Iannilli et Ruffo, 2002, the Isopod *Proasellus coxalis* (Dollfus, 1892) and Copepods *Bryocamptus* sp. and *Canthocamptus* sp.

Among Vertebrata the amphibians *Bufo bufo* (Linnaeus, 1758) and *Rana italica* Dubois,1987 occur in the cave and use the stream water to lay eggs. Finally fishes as *Squallius* sp. and *Alburnus* sp. were captured in the deep pools also 500 meters inside the cave while *Anguilla anguilla* (Linnaeus, 1758), reported in literature (Latella, 1995), was not observed during our study.

DISCUSSION

Out of the 15 families of decapods (excluding crabs) inhabiting subterranean water of the world, two shrimps and one crayfish family include the vaste majority of species (Hobbs III, 1998). In particular, the family Atyidae is represented by 49 stygobitic species and the family Cambaridae is depicted by 40 stygobitic and 35 stigophilic and stygoxenic species. Cambaridae family is a typical representant of the troglobiotic American fauna with four genera, three of which have epigean members as well (*Procambarus* Ortmann, 1905, *Orconectes* Cope, 1872, and *Cambarus* Erichson, 1846: Hobbs et al., 1977). In particular, *P. clarkii* has been found in caves of Texas (Hobbs et al., 1977), probably due to the displacement of populations living in epigean environments.

In Europe, Atyidae are represented by at least 5 species of the genus *Troglocaris* Dormitzer, 1853, occuring in caves from Balkans and Transcaucasia (Franjevic et al. 2010), while Palaemonidae by the blind prawn genus *Typhlocaris* Calman, 1909, present in Southern Italy (Apulia) with the species *T. salentina* (Caroli, 1923) (Hobbs III, 1998). On the other hand, crayfish are occasionally found in European subterranean habitats and they have been almost unknown or rarely reported. Only identified native species, such as the Astacidae *Austropotamobius torrentium* (Schrank, 1803) collected in the underground river from Divaca and Rakek in Slovenia and from Alistrati cave in Macedonia is so far reported (Hobbs III, 1998; Koutrakis et al., 2005).

Regarding the studied area, the first record of *P. clarkii* in the water bodies of the province of Latina, where the Ausi cave is located, dates back to 2002 (Gelosi & Colombari, 2004; Monaco, 2014).

In this preliminary study we can confirm the presence of the crayfish *P. clarkii* in the subterranean stream of the Ausi cave. This occurrence, in spite of our repeated samplings conducted in 2016, can be considered very recent, starting not until spring 2017.

Two ways of cave invasion can be supposed, the first throughout the big resurgence at the bottom of the cave connected with the Amaseno river. The second throughout the upper entrances placed on the overlying calcareous plateaux. Both these ways are subjected to periodical floods due to intense rainfalls as occurred during the winter and the spring 2017. In fact in this period the rainfall repertoire documents a total of 9 days with rainfall exceeding 15 mm for Prossedi locality (www. 3Bmeteo.com).

All the captured specimens show morphometric parameters according to the size variation typical of the species as indicated in Mazzoni et al. (2004).

Taxa	Latella (1995)	Our collections
ANELLIDA		
LUMBRICIDAE indet.		*
HIRUDINEA indet.		*
GASTROPODA		
Ancylus sp.		*
Bythynia sp.		*
CRUSTACEA		
COPEPODA		
Bryocamptus sp.	*	
Canthocamptus sp.	*	
AMPHIPODA		
Niphargus longicaudatus	*	*
Gammarus elvirae		*
ISOPODA		
Proasellus coxalis	*	*
INSECTA		
ODONATA		
Calopterix sp.	*	*
EPHEMEROPTERA		
Habrophlebia sp.	*	*
Coenis sp.	*	
Baetis sp.	*	*
TRICOPTERA		
Hydroptila sp.	*	
Rhyacophyla rougemonti	*	
VERTEBRATA		
PISCES		
CIPRINIDAE		
Squallius sp.		*
Alburnus sp.		*
ANGUILLIDAE		
Anguilla anguilla	*	
AMPHIBIA		
BUFONIDAE		
Bufo bufo		*
RANIDAE		
Rana italica		*

Table 2. List of aquatic species from Ausi underground stream. Data are obtainded from Latella (1995) and our collections (2016–2017).

Moreover, as expected in the case of recent cave colonization, no observed or collected individuals resulted depigmented. The presence of two shelter tunnels dugged on the river banks, can suggest a stable colonization of the underground river while the occurrence of males showing bluish pigmentation of the chelae could indicate sexual activity in the cave. Our observations seem to indicate a good tolerance of *P. clarkii* to relatively low temperature of the cave water that in all the sampling dates ranged between 13.4 and 15.0 °C. This range of temperature is close to the limit of 12.0°C beneath which the species stops its growth (Ackerfors, 1999). The lack of direct data on the diet doesn't allow us to extimate the impact of the local population of *P. clarkii* on the aquatic biocenose of the Ausi cave. However, as discussed by Mazza et al. (2014), the potential strong disturbing activity on the native aquatic community is highly predictable. In fact, although adults of *P. clarkii* are usually considered plant eater, young individuals are active predators of invertebrates (De Luise, 2010). This feeding behaviour, in absence of natural competitors and predators like carnivore fishes, birds and mammals, could result in a magnification of the negative impact on the aquatic biocenose, composed in the cave by endemic species, often limited to a single subterranean habitat and reprensented by small populations (Culver, 1982; Culver & Pipan, 2009). In the case of Ausi, the invasion of *P. clarkii* could represent a new threat for the Amphipods *Niphargus longicaudatus* and *Gammarus elvirae*, the first widespread mostly in southern-central Italy and in the Tyrrhenian islands (Karaman, 1993) and the second ones widespread in the central part of the Apennines, between Marche and Campania and recently collected in Capodacqua, the main spring of Amaseno river (Iannilli & Ruffo, 2002).

Finally, being *P. clarkii* capable to stay for a long time outside the water, as reported by many authors (see Barbaresi & Gherardi, 2000), we can strongly suppose its impact also on the terrestrial cave community.

REFERENCES

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REFERENCES

Ackerfors H., 1999. The positive effects of established crayfish introductions in Europe. In: Gerardhi F. & Holdich D.H., Crayfish in Europe as Alien Species. 1999. Crustacean 11, A.A. Balkema, Rotterdam, The Netherlands, pp. 49–61

Aquiloni L., Brusconi S., Cecchinelli E., Tricarico E., Mazza G., Paglianti A. & Gherardi F., 2010. Biological control of invasive populations of crayfish: the European eel (*Anguilla anguilla*) as a predator of *Procambarus clarkii*. Biological Invasions, 12: 3817–3824.

Barbaresi S. & Gherardi F., 2000. The invasion of the alien crayfish *Procambarus clarkii* in Europe, with particular reference to Italy. Biological Invasion, 2: 259–264.

Bodon M., Cianfanelli S. & Montanari A., 2009. Mollusks of the Frasassi karstic complex and adjacent sulfidic spring. The Frasassi Stygobionts and their Sulfidic Environment, Genga, September 10–13, 2009, p. 9–11 (Abstract).

Callot-Girardi H., Wienin M. & Galera J.L., 2012. Présence de *Corbicula fluminea* (Muller, 1774), en milieu cavernicole, dans la Cèze souterraine à Méjannes-le-Clap, Gard, France. Le perte de la Baume Salène, un site écologique confiné remarquablement riche. Folia Conchyliologica, 18: 3–14.

Culver D.C., 1982. Cave life: evolution and ecology. Harvard University Press, 189 pp.

Culver D.C. & Pipan T., 2009. The Biology of Caves and Other Subterranean Habitats. Oxford University Press, 256 pp.

Danielopol D.L., Griebler C., Gunatilaka A. & Notenboom J., 2003. Present state and future prospects for groundwater ecosystems. Enviromental Conservation, 30: 104–130.

Deharveng L., Stoch F., Gibert J., Bedos A., Galassi D., Zagmajster M., Brancelj A., Camacho A., Fiers F., Martin P., Giani N., Magniez G. & Marmonier P., 2009. Groundwater biodiversity in Europe. Freshwater Biology, 54: 709–726.

De Luise G., 2010. Il Gambero Rosso della Louisiana. Aspetti ecologici, biologici e gestionali in Friuli Venezia Giulia. Ente Tutela Pesca del Friuli Venezia Giulia, Udine, 52 pp.

Franjevic D., Kalafatic M., Kerovec M. & Gottstein S., 2010. Phylogeny of cave-dwelling atyid shrimp *Troglocaris* in the Dinaric Karst based on sequences of three mitochondrial genes. Periodicum Biologorum, 112: 159–166.

Gelosi E. & Colombari P.T., 2004. Manuale della Pesca. Ambiente, fauna, pesca, attrezzi, leggi delle acque del Lazio. Stabilimento Ittiogenico. Romana Editrice, Roma, 465 pp.

Gherardi F., 2006. Crayfish invading Europe: the case study of *Procambarus clarkii*. Marine and Freshwater Behaviour and Physiology, 39: 175–191.

Gibert J. & Culver D.C., 2009. Assessing and conserving groundwater biodiversity: an introduction. Freshwater Biology, 54: 639–648.

Hobbs H.H. Jr., Hobbs III H.H. & Margaret A.D., 1977. A Review of the Troglobitic Decapod Crustaceans of the Americas. Smithsonian Contributions to Zoology, Washington DC, 187 pp.

Hobbs III H.H., 1998. Decapoda. In: Juberthie C. & Decu V., 1998 (Eds.), Enclicopaedia Biospeologica. Societè de Biospeologiè, Moulis-Bucarest, Vol. II, 891–911.

Karaman G., 1993. Anfipodi delle acque dolci italiane. Fauna d'Italia, XXXI. Calderini., Bologna, 337 pp.

Koutrakis E.T., Machino Y., Kallianiotis A. & Holdich D.M., 2005. *Austropotamobius torrentium* (Schrank, 1803) in the Aggitis Cave (Northern Greece). Is it a cave-dwelling species? Bulletin Français de la Pêche et de la Pisciculture, 376–377: 529–538.

Iannilli V. & Ruffo S., 2002. Appennine and Sardinian species of *Gammarus*, with the description of *Gammarus elvirae* n. sp. (Crustacea Amphipoda, Gammaridae). Libera Accademia Gioenia di Scienze Naturali, 35: 519–532.

Latella L., 1995. La fauna cavernicola dei Monti Lepini. Notiziario del Circolo Speleologico Romano NS, 6–7: 76–119.

Mazza G., Reboleira A.S.P.S., Gonçalves F., Aquiloni L., Inghilesi A.F., Spigoli D., Stoch F., Taiti S., Gherardi F. & Tricarico E., 2014. A new threat to groundwater ecosystems: first occurrences of the invasive crayfish *Procambarus clarkii* (Girard, 1852) in European caves. Journal of Cave and Karst Studies, 76: 62–65.

Mazzoni D., Gherardi F. & Ferrarini P., 2004. Guida al Riconoscimento dei Gamberi d'Acqua Dolce. Greentime, Bologna, 56 pp.

Mecchia G., Mecchia M., Piro M. & Barbati M., 2003. Le Grotte del Lazio. I fenomeni carsici, elementi della geodiversità. Regione Lazio, Roma, 413 pp.

Monaco A., 2014. Alieni: la minaccia delle specie alloctone per la biodiversità del Lazio. Palombi editori., Roma, 256 pp.

Sparacio I., La Mantia T., Colomba M.S., Liberto F, Reitano A. & Giglio S., 2017. Qanat, Gebbie and water source: the last refuge for the malacologica freshwater fauna in Palermo (Sicily, Italy). Biodiversity Journal, 8: 279–310.

Zapparoli M., 2008. Primo elenco delle specie animali alloctone negli ambienti sotterranei italiani. In: Fiacchini D., Carotti G. & Fusco G., 2008, Convegno Biospeleologia dell'Appennino: studi e ricerche su Anfibi e Invertebrati, con particolare riferimento all'Appennino Umbro-Marchigiano. Parco naturale regionale Gola della Rossa e di Frasassi, GSS - CAI Senigallia, CoSteSS. Tecnostampa Edizioni srl, Ostra Vetere (AN), 71–75.

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A new species of genus *Agapanthia* Audinet-Serville, 1835 (Coleoptera Cerambycidae) from Lampedusa Island (Sicily Channel, Italy)

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ABSTRACT In this paper, a new species of *Agapanthia* Audinet-Serville, 1835, subgenus *Epoptes* Gistel, 1857 (Coleoptera Cerambycidae) from Lampedusa Island (Sicily Channel, Italy) is described. This new species belongs to the *A. asphodeli* (Latreille, 1804) species group. Taxonomic, biological and geonemic notes on *A. lopadusae* n. sp. are provided.

KEY WORDS Coleoptera; Cerambycidae; *Agapanthia*; *Epoptes*; new species; Lampedusa, Italy.

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INTRODUCTION

The *Agapanthia asphodeli* (Latreille, 1804) group consists of many species widespread in the Mediterranean basin and it was made up of 8 species until now (Hernández, 1992; Sama, 2008; Löbl & Smetana, 2010).

- *A. asphodeli* (Latreille, 1804) spread from Spain and Portugal to Southern Russia, West Kazakhstan, Balcan Peninsula and Asia Minor (locus typicus: Bordeaux, France);
- *Agapanthia schurmanni* Sama, 1979 from Southern Balcans;
- *A. nicosiensis* Pic, 1927 is endemic of Cyprus;
- *A. cretica* Bernhauer, 1978 is endemic of Kriti (Greece);
- *A. renatae* Steiner et Schmidt, 2013 from Peloponnese (Greece);
- *A. kindermanni* Pic, 1905 is endemic of South Turkey;
- *A. fadli* Sama et Rapuzzi, 2006 is endemic of North Egypt;
- *A. zappi* Sama, 1987 spread in North Africa from Lybia to Morocco.

It is very likely that, after a deeper study on this species-group, other populations can be separated from *A. asphodeli* as distinct species.

In Italy, *A. asphodeli* (Sama, 1988; 1994; 2002; 2007; Löbl & Smetana, 2010; Sama & Rapuzzi, 2011) is reported and it is also present in Sicily (Ragusa, 1924; Vitale, 1936; Sama & Schurmann, 1980; Sparacio, 1999; Sama, 2005; Baviera et al., 2017).

Particularly, *A. asphodeli* was reported to be from Lampedusa Island by Pisciotta et al. (2008). However, the study of further material from this island has allowed us to understand that these populations belong to a new species that is described below.

ACRONYMS. CB: Michele Bellavista collection (Palermo, Italy); CPR: Pierpaolo Rapuzzi collection (Prepotto, Udine, Italy); CS: Ignazio Sparacio collection (Palermo, Italy); MSNG: Museo Civico di Storia Naturale di Genova, Italy; ex/x: specimen/s.

RESULTS

Systematics

Ordo COLEOPTERA Linnaeus, 1758
Superfamilia CHRYSOMELOIDEA Latreille, 1802
Familia CERAMBYCIDAE Latreille, 1802
Subfamilia LAMIINAE Latreille, 1825
Tribus AGAPANTHIINI Mulsant, 1839
Genus *Agapanthia* Audinet-Serville, 1835
Subgenus *Epoptes* Gistel, 1857

Agapanthia lopadusae n. sp. (Figs. 1–5)

EXAMINED MATERIAL. Holotype: Italy, Sicilian Channel, Lampedusa Island, 18.II.2017, legit T. La Mantia (MSNG). Paratypes: same data of holotype, 30.III.2009, 5 exx (CS); idem, 12.III.2015, 3 exx (CS); idem, 1 ex (CB); idem, 10.III.2016, 12 exx, legit G. Maraventano (CPR); idem, 18.II.2017, legit T. La Mantia and G. Maraventano, 12 exx (CS).

DESCRIPTION OF HOLOTYPE Length: 17.2 mm. Black with bronze lustre. Head with dark and short pubescence and long and black hairs; vertex with longitudinal and large stripe of yellow pubescence; lower eyes lobes about as long as the cheeks. Pronotum a bit transverse, 1.16 as wide as it is long, wider at the base than in front, arched on the lateral sides, with big and very dense punctures and small wrinkles towards the base; covered by numerous black erect hairs and three longitudinal stripes (two on the sides and a central one) of dense yellowish pubescence. Elytra wider than the pronotum, slightly convex, elongated, 2.7 as long as it is wide, about 4 times longer than the pronotum, subparallel to the lateral sides and narrow in the apical fifth, with big and very dense punctures; they are irregularly and not densely covered by short yellow pubescence isolated or arranged in small groups and with long erect black hairs shorter at the apex; two longitudinal stripes of short and yellow pubescence are present on the sides. Scutellum rounded and interely covered by short and yellow pubescence. Apex rounded. Antennae longer than body, surpassing the elytra with the last five segments; first segment black, densely covered with appressed short pubescence black on the dorsal surface, yellow an the ventral surface; segments 3–12 predominantly reddish, blackened apically 3–5, in the apical half 6–12; segments 1–5 with long, erect and black hairs, sparse or absent from the sixth onwards. Legs relatively short and strong, tibiae arched, tarsi longer of the tibiae with third segment of anterior tarsi very elongated. Ventral surface of the body densely covered by yellow and short pubescence and long, sparse and black hairs.

Genitalia (tegmen) as in figure 4 with the manubrium divided into two separated basal apodems (subgenus *Epoptes*: see Sama, 2008); the lateral lobes are elongate, little wide, apex convex with numerous and long bristles. The endophallous shows little dense sclerifications, the paramers are elongate with the apex short.

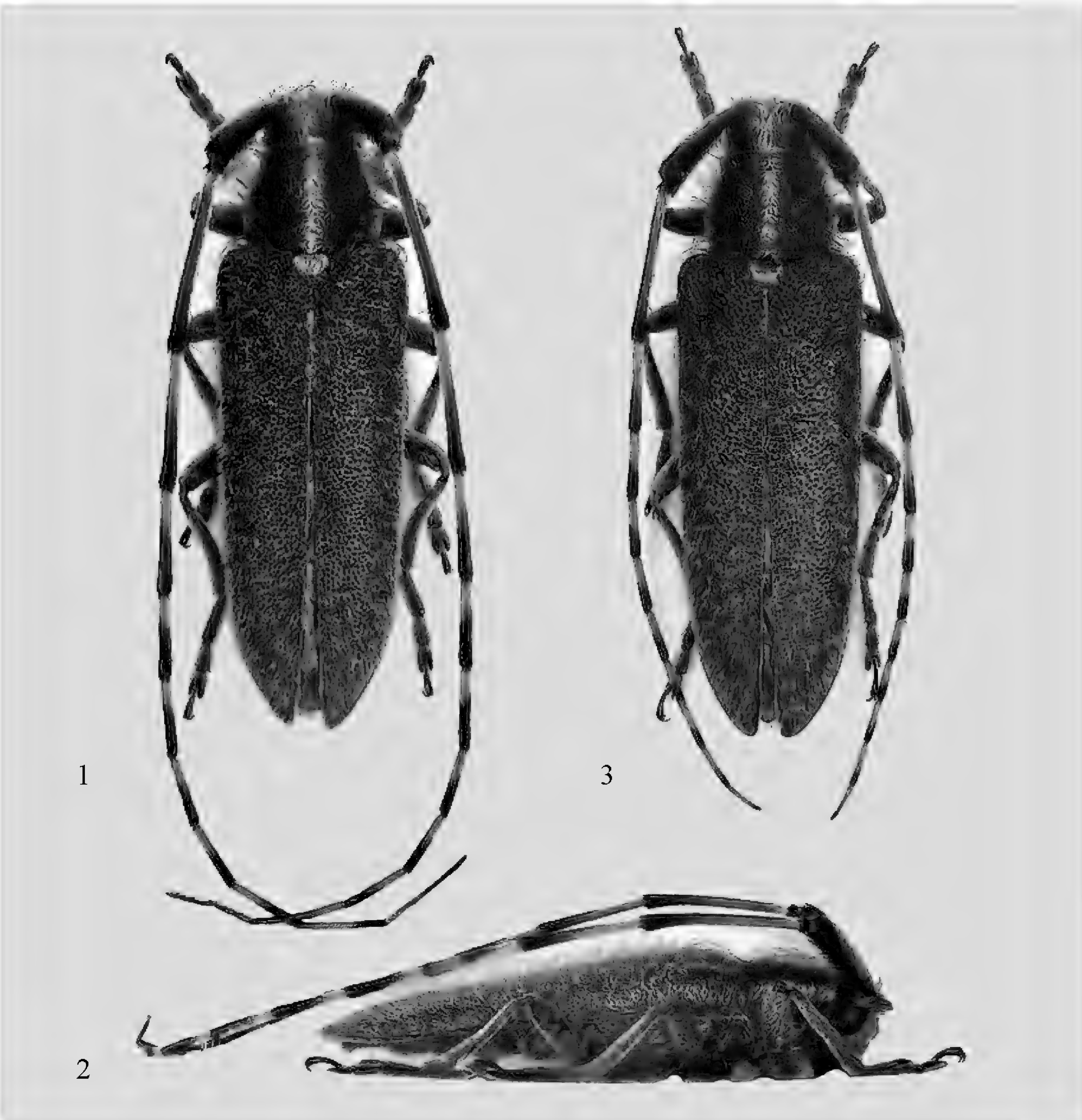
VARIABILITY. Paratypes have no substantial morphological differences from the holotype. Length: 15.2–19 mm. The females, usually, have a broader body and shorter antennae surpassing the elytral apex with the last three segments. The valvae of ovipositor are elongate and acuminate (Fig. 5).

ETYMOLOGY. The specific epithet refers to the Latin name of type locality, Lampedusa.

DISTRIBUTION AND BIOLOGY. The new species is only known from the type locality in Lampedusa Island. This island is an emergence of the African Continental platform and is located 195 Km from the Sicilian coast and 120 Km from Tunisia (Agnesi & Federico, 1995). Lampedusa includes numerous endemic species; they are differentiated by geographical isolation and often have clear North African affinities (Muscarella & Baragona, 2017).

Agapanthia lopadusae n. sp. have been captured on *Asphodelus ramosus* L. subsp. *ramosus* stems and, like others species of this group, the larva develops especially on this plant. The *A. asphodeli* species group also live on other plants like *Carduus*, *Thapsia* and *Ferula*. *Agapanthia lopadusae* n. sp. probably develops also on *Ferula*.

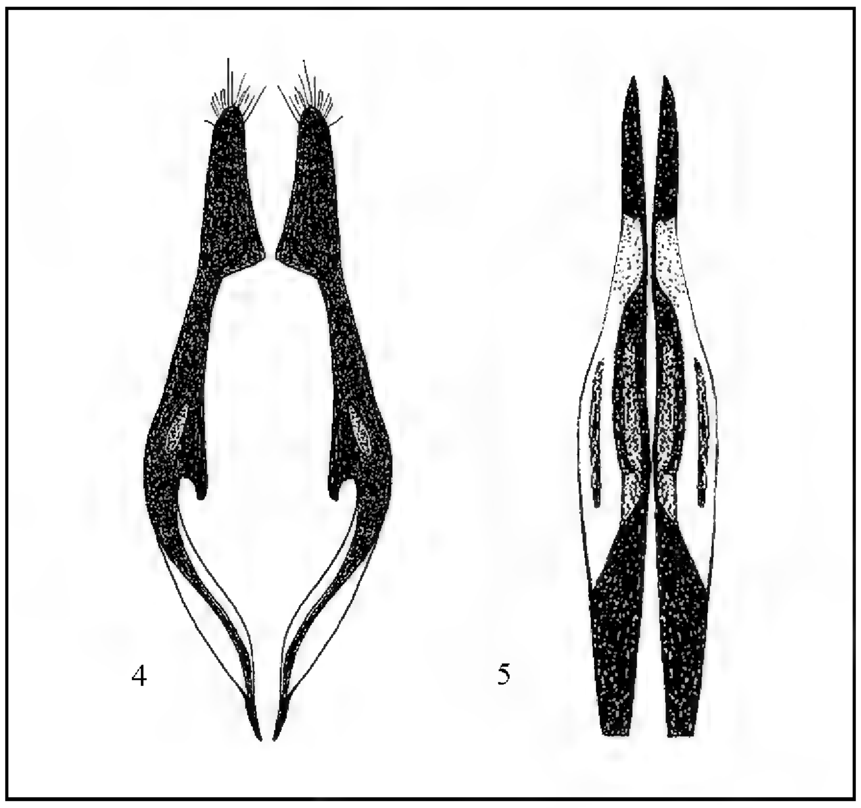
COMPARATIVE NOTES. Taking into account the very elongated third segment of the front tarsi, the new species belongs to the *A. asphodeli* species group (see Sama, 1994; 2008). It is easy to distinguish from other species of this group by the darker antennae in which the color, from the third segment, is dark-brown and not more or less light yellow. The closest known species to *A. lopadusae* n. sp. is *A.*



Figures 1–3. *Agapanthia lopadusae* n. sp. from Lampedusa Island. Figs. 1, 2: paratype male. Fig. 3: paratype female.

zappii from North Africa. The North African populations of *A. zappii* differ greatly depending on the location. It is very likely that they constitute a group of different species. For this study, we used specimens of *A. zappii* from Algeria (Ouarsenis: Teniet el Had). This place is close to the type locality (Batna). The specimens of *A. lopadusae* n. sp. have been compared to the type series preserved in Sama's collection (Cesena, Italy). The new species differs from the North African species for the denser and longer erect black hairs on elytra and pronotum, the color of the pubescence is darker and the yellow strips on pronotum and lateral sides of the elytra are made by darker pubescence as well. The punctuation of the pronotum shows denser and deeper points. The space between each point is thinner and sometimes the single points are fused with the closest one in *A. lopadusae* n. sp. This punctuation is made by sparser and less deep points in *A. zappii*. From the other North African species like *A. fadli* (Sama & Rapuzzi, 2006), known only from few localities close to Alexandria in Northern Egypt, the

new species is easy to distinguish by the denser long erect hairs on the inner side of all the antennal segments, from the third to the fifth. These hairs are missing in the Egyptian species and are very scattered in *A. zappii* from Algeria. Following this morphological characteristic, this new species is closer to *A. asphodeli*, described from Bordeaux (France). Nonetheless, it can be easily distinguished by the darker color of the antennal segments, the darker pubescence of the body and for the stronger punctuation on elytra and pronotum. The points on the elytral base are arranged in more or less evident wrinkles in the new species and they are perfectly separated in *A. asphodeli*. The erect black hairs on the whole body are longer and denser in the Lampedusean species than in any other species. The sclerites of the endophallous are less dense and sclerificated than in any other species of this group, the paramers are long with the apex shorter than in *A. zappii*, but a little longer and stouter than in *A. asphodeli* and *A. fadli*, being more closely related to *A. nicosiensis* from Cyprus and resembling *A. zappii* from North Africa. *Agapanthia nicosiensis* differs from the new species by the absence of the longitudinal stripe of grey pubescence along the lateral margin of elytra, the absence of transverse wrinkles on pronotal disc, which is more or less irregularly and deeply punctate, the elytra more densely covered with recumbent pubescence and with erect hairs up to the apex. *Agapanthia zappii* differs from the new species by the puncturation of pronotum, the conspicuously denser elytral ground pubescence (like in *A. asphodeli*), the antennae, except the scape, are very sparsely ciliate on their inferior side, the third segment has no tuft of hairs at the apex. Because of the elytral lateral stripe of grey pubescence, *A. fadli* was confused with *A. lateralis* Ganglbauer, 1884. This species, that lives only in Turkey, is easily distinguishable by the third segment of the front legs that is transverse, not longer than it is wide, and by the pronotal disc without transverse wrinkles. *Agapanthia pustulifera* Pic, 1905 (from the Near East), which has the pronotal disc transversely wrinkled like the new species, is easily recognizable by the transverse third segment of the front tarsi, pronotum with a short median tubercle on each side, elytra covered with much shorter and sparser ground pubescence and without a lateral stripe of grey pubescence.



Figures 4, 5. Genitalia of *Agapanthia lopadusae* n. sp. from Lampedusa Island. Fig. 4: tegmen of the male. Fig. 5: female ovipositor.

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REFERENCES

Agnesi V. & Federico C., 1995. Aspetti geografico-fisici e geologici di Pantelleria e delle Isole Pelagie (Canale di Sicilia). In: Massa B. (Ed.), Arthropoda di Lampedusa, Linosa e Pantelleria (Canale di Sicilia, Mar Mediterraneo). Il Naturalista siciliano, 19 (Suppl.): 1–22.

Baviera C., Bellavista M., Altadonna G., Turrisi G.F., Bella S., Muscarella C. & Sparacio I., 2017. The Cerambycidae (Coleoptera: Chrysomeloidea) of Sicily: recent records and updated checklist. Atti della Accademia Peloritana dei Pericolanti Classe di Scienze Fisiche, Matematiche e Naturali, 95: 1–79.

Hernández J.M., 1992. Study of the female genitalia of the genera *Agapanthia* Serville, 1835 in the Iberian Peninsula and its taxonomical application (Coleop-

tera, Cerambycidae, Lamiinae). Actas do V Congresso Ibérico de Entomologia, Supl. 3. Boletim da Sociedade Portuguesa de Entomologia, 2: 499–502.

Löbl I. & Smetana A. (Eds.), 2010. Catalogue of Palearctic Coleoptera. Volume 6. Chrysomeloidea. Apollo Books, Stenstrup, 924 pp.

Muscarella C. & Baragona A., 2017. The endemic fauna of the Sicilian islands. Biodiversity Journal, 8: 249–278.

Pisciotta S., Sajeva M. & Sparacio I., 2008. New records of Coleoptera Cerambycidae for Lampedusa Island (Pelagian Is., Sicily). Il Naturalista siciliano, 32: 405–409.

Ragusa E., 1924. I Cerambycidae della Sicilia. Bollettino della Reale Accademia delle Scienze, Lettere e Belle Arti di Palermo, 14: 1–33.

Sama G., 1994. Deuxième note sur les Cerambycides de Chypre. Revision de la collection du Department of Agriculture de Chypre avec description d'un nouveau *Leiopus* Serville et de deux *Trichoferus* Wollaston du Ciste. Biocosme Mésogéen, 11: 37–47.

Sama G., 1988. Coleoptera Cerambycidae. Catalogo Topografico e Sinonimico. Fauna d'Italia, XXV. Bologna, Calderini, 216 pp.

Sama G., 1994. Coleoptera Polyphaga XIV (Cerambycidae). In: Minelli A., Ruffo S. & La Posta S. (Eds.), Checklist and distribution of the Italian fauna. Vol. 59. Calderini, pp. 1–12.

Sama G., 2002. Atlas of the Cerambycidae of Europe and the Mediterranean Area. Volume 1: Northern, Western, Central and Eastern Europe. British Isles and Continenal Europe from France (excl. Corsica) to Scandinavia and Urals. Nakladatelstvi Kabourek: pp. 1–173.

Sama G., 2005. Insecta Coleoptera Cerambycidae. In: Checklist e distribuzione della fauna italiana. Ed. by S. Ruffo and F. Stoch. Memorie del Museo Civico di Storia Naturale di Verona, 2. Serie, Sezione Scienze della Vita 16, pp. 219–222.

Sama G., 2007. Fauna Europea: Coleoptera, Cerambycidae. In: Audisio P., Fauna Europaea: Coleoptera: 2. Fauna Europaea version 1.3, http://www.fauna-eur.org

Sama G., 2008: Notes on the genus *Agapanthia* Serville, 1835. Boletin Sociedad Entomologica Aragonesa, 42: 123–127.

Sama G. & Schurmann P., 1980. Coleotteri Cerambicidi di Sicilia. Animalia, 7: 189–230.

Sama G. & Rapuzzi P., 2006. Preliminary report on a recent survey of the Egyptian Cerambycidae, with description of three new species. (Insecta Coleoptera Cerambycidae). Quaderno di Studi e Notizie di Storia Naturale della Romagna, 23: 179–194.

Sama G. & Rapuzzi P., 2011. Una nuova Checklist dei Cerambycidae d'Italia. Quaderno di Studi e Notizie di Storia Naturale della Romagna, 32: 121–164.

Sparacio I., 1999. Coleotteri di Sicilia. Parte III. L'Epos, Palermo.

Vitale F., 1936. I longicorni siciliani. Atti della Reale Accademia Peloritana. Classe di Scienze Fisiche, Matematiche e Biologiche, 14: 75–101.

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